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ONS' HOME
READING BOOKS

IN BROOK AND BAYOU

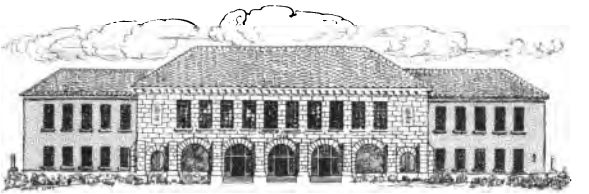
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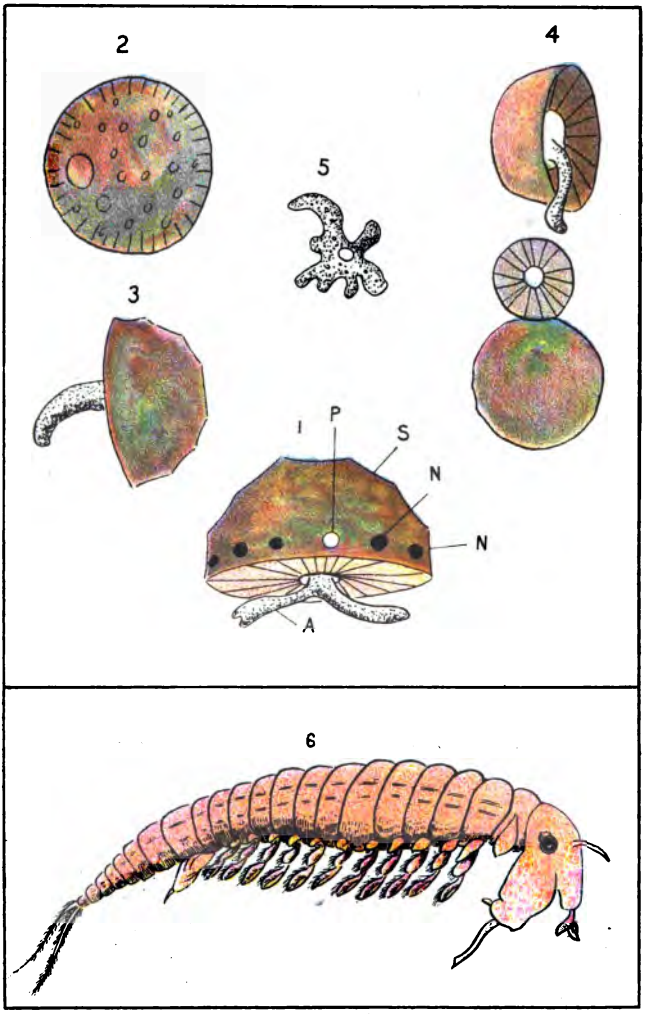
WILLIAM T. HARRIS, A. M., LL. D.

UNITED STATES COMMISSIONER OF EDUCATION

DIVISION I

NATURAL HISTORY

CHART I.



Arcellae—Fairy Shrimp.

APPLETONS' HOME READING BOOKS

IN BROOK AND BAYOU

OR, LIFE IN THE STILL WATERS

BY

CLARA KERN BAYLISS

He liveth best who loveth best
All things, both great and small



NEW YORK
D. APPLETON AND COMPANY
1897

DEPARTMENT OF EDUCATION
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INTRODUCTION TO THE HOME READING BOOK SERIES BY THE EDITOR.

THE new education takes two important directions—one of these is toward original observation, requiring the pupil to test and verify what is taught him at school by his own experiments. The information that he learns from books or hears from his teacher's lips must be assimilated by incorporating it with his own experience.

The other direction pointed out by the new education is systematic home reading. It forms a part of school extension of all kinds. The so-called "University Extension" that originated at Cambridge and Oxford has as its chief feature the aid of home reading by lectures and round-table discussions, led or conducted by experts who also lay out the course of reading. The Chautauquan movement in this country prescribes a series of excellent books and furnishes for a goodly number of its readers annual courses of lectures. The teachers' reading circles that exist in many States prescribe the books to be read, and publish some analysis, commentary, or catechism to aid the members.

Home reading, it seems, furnishes the essential basis of this great movement to extend education

beyond the school and to make self-culture a habit of life.

Looking more carefully at the difference between the two directions of the new education we can see what each accomplishes. There is first an effort to train the original powers of the individual and make him self-active, quick at observation, and free in his thinking. Next, the new education endeavors, by the reading of books and the study of the wisdom of the race, to make the child or youth a participator in the results of experience of all mankind.

These two movements may be made antagonistic by poor teaching. The book knowledge, containing as it does the precious lesson of human experience, may be so taught as to bring with it only dead rules of conduct, only dead scraps of information, and no stimulant to original thinking. Its contents may be memorized without being understood. On the other hand, the self-activity of the child may be stimulated at the expense of his social well-being—his originality may be cultivated at the expense of his rationality. If he is taught persistently to have his own way, to trust only his own senses, to cling to his own opinions heedless of the experience of his fellows, he is preparing for an unsuccessful, misanthropic career, and is likely enough to end his life in a madhouse.

It is admitted that a too exclusive study of the knowledge found in books, the knowledge which is aggregated from the experience and thought of other people, may result in loading the mind of the pupil with material which he can not use to advantage.

Some minds are so full of lumber that there is no space left to set up a workshop. The necessity of uniting both of these directions of intellectual activity in the schools is therefore obvious, but we must not, in this place, fall into the error of supposing that it is the oral instruction in school and the personal influence of the teacher alone that excites the pupil to activity. Book instruction is not always dry and theoretical. The very persons who declaim against the book, and praise in such strong terms the self-activity of the pupil and original research, are mostly persons who have received their practical impulse from reading the writings of educational reformers. Very few persons have received an impulse from personal contact with inspiring teachers compared with the number that have received an impulse from such books as Herbert Spencer's Treatise on Education, Rousseau's Émile, Pestalozzi's Leonard and Gertrude, Francis W. Parker's Talks about Teaching, G. Stanley Hall's Pedagogical Seminary. Think in this connection, too, of the impulse to observation in natural science produced by such books as those of Hugh Miller, Faraday, Tyndall, Huxley, Agassiz, and Darwin.

The new scientific book is different from the old. The old style book of science gave dead results where the new one gives not only the results, but a minute account of the method employed in reaching those results. An insight into the method employed in discovery trains the reader into a naturalist, an historian, a sociologist. The books of the writers above named have done more to stimulate original research on the

part of their readers than all other influences combined.

It is therefore much more a matter of importance to get the right kind of book than to get a living teacher. The book which teaches results, and at the same time gives in an intelligible manner the steps of discovery and the methods employed, is a book which will stimulate the student to repeat the experiments described and get beyond these into fields of original research himself. Every one remembers the published lectures of Faraday on chemistry, which exercised a wide influence in changing the style of books on natural science, causing them to deal with method more than results, and thus to train the reader's power of conducting original research. Robinson Crusoe for nearly two hundred years has stimulated adventure and prompted young men to resort to the border lands of civilization. A library of home reading should contain books that stimulate to self-activity and arouse the spirit of inquiry. The books should treat of methods of discovery and evolution. All nature is unified by the discovery of the law of evolution. Each and every being in the world is now explained by the process of development to which it belongs. Every fact now throws light on all the others by illustrating the process of growth in which each has its end and aim.

The Home Reading Books are to be classed as follows:

First Division. Natural history, including popular scientific treatises on plants and animals, and also de-

scriptions of geographical localities. The branch of study in the district school course which corresponds to this is geography. Travels and sojourns in distant lands; special writings which treat of this or that animal or plant, or family of animals or plants; anything that relates to organic nature or to meteorology, or descriptive astronomy may be placed in this class.

Second Division. Whatever relates to physics or natural philosophy, to the statics or dynamics of air or water or light or electricity, or to the properties of matter; whatever relates to chemistry, either organic or inorganic—books on these subjects belong to the class that relates to what is inorganic. Even the so-called organic chemistry relates to the analysis of organic bodies into their inorganic compounds.

Third Division. History and biography and ethnology. Books relating to the lives of individuals, and especially to the social life of the nation, and to the collisions of nations in war, as well as to the aid that one gives to another through commerce in times of peace; books on ethnology relating to the manners and customs of savage or civilized peoples; books on the primitive manners and customs which belong to the earliest human beings—books on these subjects belong to the third class, relating particularly to the human will, not merely the individual will but the social will, the will of the tribe or nation; and to this third class belong also books on ethics and morals, and on forms of government and laws, and what is included under the term civics or the duties of citizenship.

Fourth Division. The fourth class of books includes more especially literature and works that make known the beautiful in such departments as sculpture, painting, architecture and music. Literature and art show human nature in the form of feelings, emotions, and aspirations, and they show how these feelings lead over to deeds and to clear thoughts. This department of books is perhaps more important than any other in our home reading, inasmuch as it teaches a knowledge of human nature and enables us to understand the motives that lead our fellow-men to action.

To each book is added an analysis in order to aid the reader in separating the essential points from the unessential, and give each its proper share of attention.

W. T. HARRIS.

WASHINGTON, D. C., *November 16, 1896.*

PREFACE.

In the study of animals, children are compelled to begin in the midst of things, and thus they never come to appreciate the significance of the various phases in the development of life, for the reason that nearly all the works on zoölogy dismiss the Protozoans and other microscopic animals either with the briefest mention or with no mention at all.

Yet it is here that we must look for the very sources of things, without some idea of which no one can apprehend the gradual evolution of life in its higher forms nor appreciate any living thing at its true value.

It is hoped that this little book may aid the child in beginning at the beginning, and obtaining a connected view of the relations of the facts that he will acquire as he advances in the study of animal life.

The plates have been prepared to represent not merely the *organs* but also the *actions* of these animals, so as to render a microscope unnecessary, although the use of one would add to the interest of the study.

The author might claim, with truth, to have written this little volume for the purpose of enriching the child's life by teaching him how much more interesting the world is than it ordinarily seems; and this is one object of the book; but, to be honest, the real reason for the writing of the book was to please herself, and because she is fond of these microscopic creatures, and would have the boys and girls enjoy them with her.

C. K. B.

CHICAGO, *February, 1897.*

AUTHOR'S INTRODUCTION.

THINGS known to us are divided into four great kingdoms—the mineral, the vegetable, the animal, and the spiritual. In the mineral kingdom there is popularly supposed to be no life. The mineral grows by accretion, by adding like particles to the outside. It has no power to create new substances. Plants and animals grow by assimilation, by eating and digesting food, by taking particles of matter and transforming them into entirely new substances, and depositing them on the *inside*. Because they have this power to create new forms of matter, they are said to be alive.

The lower forms of animals are almost indistinguishable from plant forms, yet there is a wide difference between the animal and vegetable kingdoms. The very name animal, from *animus*, mind, shows that the possessor is allied to the spiritual kingdom. The lowest animal has what the plant has not—volition or power of choosing, if it be only the choice of moving or remaining at rest.

In this book we have considered a low order of unicellular plants, the *Desmids* and *Diatoms*, which may be said to have been *caught in the act* of turning into animals; yet even here we have found phenomena of marvelous interest and prophecies of greater things to come.

We have studied the lower animals, single-celled *Protozoans*, closely allied to plants, almost wholly undiffer-

entiated in organs or functions, reproducing by spores as the lower plants do, or by cutting off a piece of themselves as plants propagate from slips. We have gone on through the *Protozoans*, finding matter differentiated into muscle, as in the *Vorticella;* into eyespots, as in the *Euglena;* into cilia, into œsophagus, and even into the permanent legs of the *Euplotes*—and all this in simple, one-celled animals.

Higher in the scale of being we find the multicellular worms and *Hydræ*, the latter with their cells arranged in two layers forming a hollow digestive tube, but still so undifferentiated in function that the two layers can readily exchange work and location. The animals still propagate by slips; yet here, in some instances, begins the production of offspring by eggs, corresponding to the propagation by seed in the *Phœnogams* or higher plants. Next we find in the *Rotifers* a distinct reproduction by egg; a differentiation of matter into mastax, eye, and even brain, as well as into sex. In *Crustaceans* we have highly specialized animals, with a great number of organs, as gills, legs, antennæ, eyes, hearts, and mouth parts.

In the *Brachionus*, redoubling its energy at the prospect of food, we have an indication of mind; in the *Canthocamptus* blaming its companion and retaliating—is it going too far to say we have psychological phenomena — one mind estimating what is in another? and that here we catch a glimpse of the spiritual kingdom? At any rate, when you go a step further and note the hostile attitude of the crayfish, the bee, or the wasp, the moment you appear upon the scene, it will no longer be possible to doubt that you are observing conduct dictated by an intelligence which is dimly self-conscious, and which recognizes intelligence and purpose in you.

In this study, as in all your zoölogical studies, you will notice:

1. That in the beginning, organs as well as animals are much alike; that differentiation or evolution starts in protoplasm and works up from the general to the special; that organs of locomotion, sight, respiration, circulation, etc., have not been made "out of hand," but have grown by use, as intellectual faculties do.

2. That there are in the earliest living things incipient prophecies of organs and faculties to come, and that few, if any, of the prophecies are yet wholly fulfilled even in man; for instance, there is promise in the *Diatom* of a unison and harmony of action to which man has not attained, and of a mode of locomotion which he has not perfected.

3. That in addition to the development of physical function there is a slow but continuous progress in mental function or intelligence.

4. When the latter reaches the point manifested in human kind, notice the hints of how man takes up and carries forward Nature's work, making new pseudopods, eyes, etc., for himself; and reflect upon what bearing this has on the proposition that man is Nature's final effort in the animal line.

This volume treats of but a limited number of the aquatic objects, and there are other fields of research which will be found of absorbing interest. In botany, entomology, crystallography, embryology, and many other departments of science, the microscope is invaluable, and its revelations are an unfailing source of surprise and profit. But the isolated facts to be gathered in this way are comparatively valueless unless their relation to other facts, their place in the continuity of facts, is understood. In other words, it may be of interest to know that an animal has a certain kind of eye or heart, but it is of vastly more interest to know what o'clock that indicates in the gradual evolution of eyes and hearts; for evolution is, after all, the paramountly significant and inspiring truth which science teaches.

BIBLIOGRAPHY.—For the beginner in the study of zoölogy, such works as Stokes's *Microscopy for Beginners*, the method of observation exemplified in Colton's *Zoölogy* and Huxley's *The Crayfish*, and the classification of *Crustacea* and *Protozoa* in the *Encyclopædia Britannica*, will be found very helpful. For those more advanced, we recommend Kent's *Manual of Infusoria*, Bronn's *Klassen und Ordnungen des Thierreichs*, and the various works on comparative anatomy.

THE AUTHOR.

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DIATOMACEÆ.

PROTOZOANS.

Gymnomixa.

- LOBOSA — Amœba. / Arcella.
- HELIOZOA — Actinophrys. / Clathrulina.

Corticata.

- FLAGELLATA — Euglena.
- RHYNCHO-FLAGELLATA — Noctiluca.
- CILIATA
 - Peritricha — Vorticella. / Vaginicolinæ.
 - Heterotricha — Stentor.
 - Holotricha — Paramœcium. / Trachelocerca. / Amphileptus. / Coleps.
 - Hypotricha — Chilodon. / Euplotes.

METAZOANS.

- VERMES.
- ROTIFERA.
- CRUSTACEANS
 - Branchiopod — Daphnia. / Branchipus.
 - Lophyropod — Cypris. / Cyclops. / Canthocamptus. / Diaptomus.
- ACALEPHS — Hydroids.

IN BROOK AND BAYOU.

CHAPTER I.

RHIZOPODS.

THE SLOWEST THING ON EARTH.

(*Amœba.*)

ANYONE who makes good use of his eyes knows that there is a multitude of things to be seen everywhere which escape the attention of the careless observer. There are beautiful tints on the flowers, odd shapes among the leaves, curious rocks that look like and *are* petrified animals, wonderful insects, and many other interesting things which he could easily pass unheeded.

But the keenest-eyed person might stand by a wayside pool without ever guessing what a host of queer people inhabit it. There are more colors and kinds of people in a little stagnant pond than are to be found in all the countries you read about in your geographies.

You do not see them because most of them are so modest and shy that they never allow mortal eye to look upon them except through a powerful magnifying glass.

They are well worth the trouble of seeking, for they are a strange sort of folk when

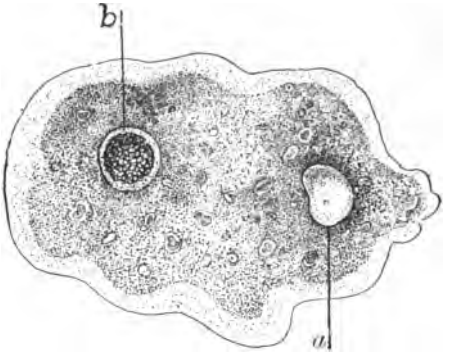


FIG. 1.—An Amœba: *a*, pulsating vacuole; *b*, nucleus.

you find them, some of them having neither eyes, ears, mouths, hands, nor feet, and yet managing to live very comfortably.

I want to tell you about one of these headless races of the pool known as the

AMŒBA FAMILY.

The first curious thing about them is that they are all ladies. There isn't a man or boy among them.

They are very domestic and seldom travel abroad. The smallest pond is an immense world to them, and has many unexplored regions like those on your maps around the north and south poles.

And yet, as you become acquainted with them, you will find these ladies very entertaining company. If you dip one up in a drop of water and put her under your microscope, you will be quite fascinated with her; yet all you'll see will be something resembling a tiny spatter of water with a few colored specks in it. But it is *alive*, and that is why it fascinates you.

Amœbæ are made of *protoplasm*, a jelly-like substance not unlike the white of an egg. Yet they can move and eat and breathe and rear children, all after a fashion of their own.

You may see them do all these things with your microscope.

They have wills of their own, too. And that is the whole secret of their eating and walking without mouths or feet.

That, I suspect, is the whole secret of being an animal at all, instead of a plant or a rock—to *will* or want to do things.

So, when an amœba wants to take a morning walk, it uses its will power to thrust out a

loop or prong of its outer covering, and then the granular part of its body flows into it.

Did you ever before hear of a creature that walked by flowing?

When it wishes to take another step, it pushes out another loop and flows into that.

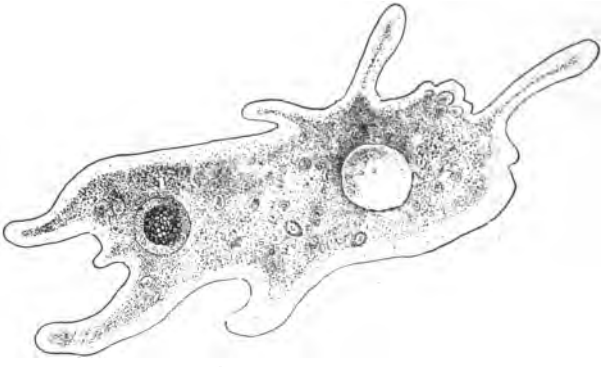


FIG. 2.—Walking.

But the amœba is slower than time—a great deal slower!

If you wish to see how much our mode of travel resembles theirs, just watch a baby creeping. Or go up into one of those large city buildings which have an open court in the center, like the Chamber of Commerce or the Masonic Temple in Chicago, and look down over the railing from the upper story upon the people crossing the court on the ground floor.

They do not look in the least like men. They have no height. They look like black or gray knobs, and their legs seem to be nothing but horizontal protuberances stretching forward at the front and withdrawing at the rear.

Try it some time. It will make you laugh to see what a queer object a walking man is when viewed perpendicularly; and that is the way in which you look at the amœba.

But you must remember that there is this difference between a man's walk and an

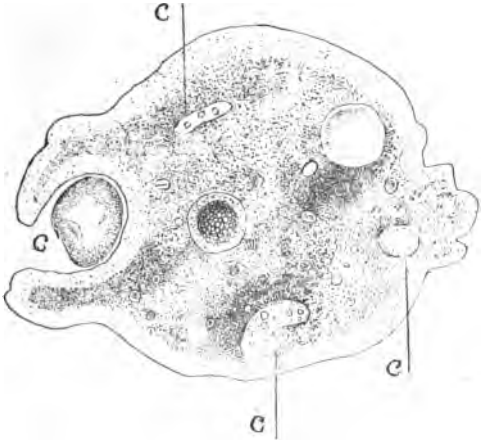


FIG. 3.—Twenty minutes for dinner: *c*, food particles.

amœba's—the man's is very much swifter. It would take an amœba a week to cross the court, small as it is.

The feet which the amœba makes when it wishes to travel are called *pseudopodia*, or "make-believe feet," because they are not real feet and do not remain when made, but become part of the body again, and will perhaps be make-believe arms to grasp something the next time they are thrust out.

Possibly you have heard people in a railway carriage, if they are addicted to slang, say, "Let's go out and throw ourselves around some food," when the conductor called "Twenty minutes for dinner."

That is what the Amœbæ do. They throw themselves around their food. Only these leisurely ladies take their time to it.

As they have no mouths into which to put their food, they manage in this way: When they come in contact with a particle of nutriment, they make arms to take it, in the same way that they made feet, by bulging out a loop of their clear outer margin and flowing into it. In this manner they flow around their food, or throw themselves around it, and wrap it up within them.

No doubt they are delighted whenever they secure a morsel. I once knew a little boy, just learning to feed himself, who took his tiny fork and speared after the morsels on

his plate, and each time he captured one he laughed and exulted, holding it up and calling on all those at the table to rejoice with him over his achievement. He *gloated* over each mouthful before he ate it.

And in their demure way the amœbæ exult over every particle of food they find, and consider it a delicious tidbit, though it really is only a bit of slimy moss or ooze from the bottom of the pond. But they like it, growing and thriving upon it.

They can not digest it as you do your food, for they have no stomachs except such as they make on demand; but they absorb it as you do the medicines you put on the outside to cure an aching head or a sore throat.

When they have extracted all the nourishment from the moss, they eject the refuse from any part of their bodies, or, to describe the operation more accurately, they roll themselves away from it.

If you watch an amœba, you will see a small bubble or opening coming in the granular part of its body. This enlarges until, through the microscope, it looks almost large enough to admit the top of your pencil. Then it closes slowly, though in much less time than was required for its coming.

This bubble comes and goes with great regularity. It is called a pulsating vacuole, or "beating emptiness," and is the nearest approach to a heart which the amœba has.

.

One morning a company of Amœbæ were holding a festival near the edge of the pond.

They were gathered about the roots of a tree which stood partly in the water. It was raining, and they were unusually happy, for the waters were roiled, and many particles of food came floating up to be wrapped in their embraces. They had not been as well fed nor as jolly for a long time. The summer had been so hot and the temperature had so often risen to one hundred degrees that they had been "heat-stiffened" most of the time and unable to get about or to eat or to enjoy life; for extreme heat as well as extreme cold renders an amœba stiff and apparently dead.

But now the sun was overcast by clouds, the cool rain was falling, and the ladies in the water had quite recovered their health and spirits, and were very merry for such sedate people as they.

But suddenly a flash of lightning came down the tree, splashing the water at its roots into the air. And every Amœba within

ten feet of the tree was rolled into a ball and lay motionless as in death. The water seemed to be full of corpses.

Those nearest the tree were indeed corpses and never wakened more. But those farther away, who had not received so strong a charge of electricity, remained in a trance for awhile, then slowly revived and unrolled themselves, and after a time began to move and eat once more.

When the Amœbæ came to life and found that some of their companions were dead, they felt very sad. They did not weep. How could they, when they had no eyes from which the tears could fall, and no hands to hold their pocket-handkerchiefs?

But they were lonesome, and wanted more Amœbæ to take the places of those who were dead.

Some said it was too soon to think of filling the vacant chairs. But others disapproved of delay, and suggested that there might be improved modern methods for replacing their loss.

"Now I've heard," said one bright Amœba lady, "that there are strange folk in foreign lands who have fathers and mothers and whole shoals of children in their families. The Snail,

who is a great traveler, a regular Wandering Jew of a fellow, and who has circumnavigated the Bayou and has gone far out beyond our world to a distant country known as 'The River,' says that in that country are barbarous heathen people, called Fishes, who have families of that sort, with menfolk at the head of them.

"But he says, too, that these Fishes have eyes, mouths, fins, gills, scales, and a great many other useless things with which we are not burdened.

"So, as we are not like them, it might be a risky experiment for us to try to imitate them in our family matters."

Another said: "The Bible* tells us that when the Creator wanted inhabitants on earth, he split a one-stemmed rhubarb stalk down the middle and it became two people.

"That was the Creator's way, and it has always been our way, and I think we'd better abide by the traditions of the past and not try newfangled methods."

So they ate and grew and expanded their bodies till there came a second nucleus and a second "beating nothingness."

* The Amœbæ read the Zend-Avesta, the Parsee Bible.

Then, on opposite edges of the body between the two nuclei, there came two indentations which deepened and deepened until they met in the middle. And behold! there were two creatures instead of one.

Every time an amœba divides into two, both new beings are born into new life, and

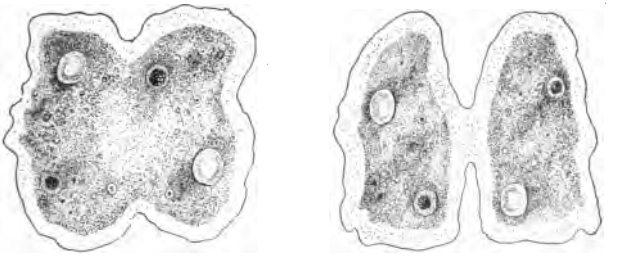


Fig. 4.—Multiplication by division.

there is no waste or dead body to leave behind.

When these two divide again, there are four new and perfect animals.

And this is how it comes to pass that the Amœbæ have done a thing which neither fish nor fowl nor man has ever succeeded in doing, though many of the latter have tried.

Ponce de Leon came to America in the early days after its discovery and hunted all up and down the forests and along the rivers

for a Fountain of Youth which was said to prevent men from growing old.

Many alchemists have spent their lives trying to make an Elixir of Life which should ward off death and keep people forever vigorous and young. No man has ever found just this thing. (I will tell you some day how near he has come to it.) But the very first Amœba that ever lived drank at the fountain and partook of the elixir which keeps the Amœbæ from age and death.

This is one of the most remarkable things about these wonderful little beings—that they and their cousins, the Paramœcii, the Bell animalcules, and all the one-celled Protozoans, never die. They may be killed or may die from accident, but there is no such thing as *natural* death among them. They are always cut off in the prime of life, as men prefer to be who have a horror of being sick in bed or dying of feebleness and age.

So they go on to this day, increasing their numbers by dividing through the middle; and are always immortal, living forever, unless some dire disaster befalls them.

.

By this way of making two out of one you will see that the people in the pond use a

different arithmetic from yours. When they want to *multiply*, they *divide*. Their arithmetic says:

"When any thing or number is divided into two equal parts, each of the parts is called a *whole one*. Two halves equal two whole ones."

$$2 \times \tfrac{1}{2} = 2 \qquad 1 \div 2 = 2.$$
$$2 \times \tfrac{2}{2} = 4 \qquad 2 \div 2 = 4.$$

And their algebra says:

Let $x = 1$ amœba,
and $y = \frac{1}{2}$ amœba.

Then $x + y = \frac{3}{2} = 3.$
$x - y = \frac{1}{2} = 1.$
$(x + y) + (x - y) = 3 + 1 = 4.$

$2x = 4$. So $x =$ *two* instead of *one* amœba. Oh, you would never get on in their algebra.

.

But if you like these little creatures and want them always near you, I will tell you a secret if you'll never reveal it to any of the ladies who call upon me.

When the ponds are frozen over, a vase of water in which nasturtium slips are growing is their favorite Winter Palace.

You can put the vase in the drawing-room window and have beautiful flowers all winter,

and people will admire your "lovely *jardinière*," though they might be horrified if they suspected that it was a menagerie containing a dozen different kinds of living animals.

II.

UNDER A HAT.

(*Arcella.*)

Some of the missionaries who distributed clothing to the naked savages in the tropic countries tell us that the natives were not satisfied with their allotment of garments, so

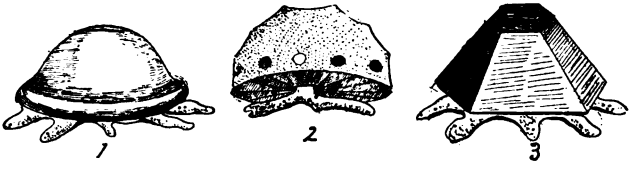


FIG. 5.—1, Arcella acuminata; 2, arcella vulgaris; 3, arcella dentata.

they traded among themselves, and when they came to services on the following day their appearance was most grotesque and astonishing. A woman would be attired in a man's shirt, or a stalwart man would stalk proudly in,

wearing, as his only article of apparel, a lady's bonnet.

Now the Amœbæ never wear clothing. But they have some near kinsmen, the Crown Amœbæ, or Arcellæ, who are much more aristocratic, the adults seldom appearing in public without a hat.

This is their only garment, but it is large enough to cover the whole body when they retract their pseudopodia, or extemporized limbs, and remain at rest.

They make their hats themselves by exuding from their bodies a chitinous substance, which shapes itself into a shell so thin and transparent that the movements of the arcella may be seen through it. These shells or hats are flexible, and sometimes the arcella rolls the brim up or bends it down as girls do with the brims of their flats or sailor hats.

When seen from above, these hats look like flat disks or plates, with delicate markings and tintings on them. There are browns and greens and yellows, from the darkest to the lightest.

When these pretty shells lie at rest on the slide of your microscope, you may easily mistake them for plants or dead matter; but when the tiny plate begins to crawl about, there is

no mistaking the active will which propels it. You know there is a live being underneath, even if you do not see the animal extending its pseudopodia beyond the shell, as you often may.

A side view shows you the true shape of the shell, as in Chart I, Figs. 1 and 4.

The arcella itself is exactly like the amœba in appearance and habits. It walks, eats, and digests in the same way; but it is distinguished by having a hat or house, by two or three nuclei, and by the manner of getting offspring.

Instead of dividing into two, as the amœba does, the arcella increases its family by what is known as "bud fission"—that is, it puts forth pseudopods on which warts or buds appear, and after a time it pinches them off, several at a time, so that it often has a family of nine children all of an age. Just think what a time there would be of it if they should all catch the measles or whooping-cough!

And these are real babies, not grown-up folks like the new-made Amœbæ; for the young Arcellæ have to develop pulsating vacuoles for themselves, and, like the children of all primitive people, they are allowed to go without clothing till they are old enough to

make it for themselves. Then they make their pretty hats and feel clothed and in their right minds, equipped for the business of life.

There is another thing which distinguishes them from the Amœbæ. The Amœbæ can not swim nor float, but have to crawl on the mud at the bottom of the pool or on sticks and leaves. But the Arcellæ have little bladders in which to secrete gas, and when the bladder is filled they can rise to the top or float in the water as an aëronaut does in the air with his balloon. When they wish to sink to the bottom they do as the man in the balloon does, they open a valve and let out the gas.

Who would have suspected that away down in the mud of the bayou we should find a prophecy of man's latest invention? Or a little creature who has gone "up in a balloon, boys, up in a balloon" so many times and for so many ages that it is no marvel at all to him or to his fellows? And they never think of taking their machine to country fairs and astonishing the natives with it.

Nature has been working up the balloon trade for ages past, you see.

There are three families of the Arcellæ—the *Acuminata*, the *Dentata*, and the *Mitrata* —and "by their hats shall ye know them," for

each family wears its own peculiar hat, as the Scottish clans used to do.

Only the Scotch called theirs bonnets, and made songs about them, and used them as other people do flags, to distinguish the armies when they go to battle.

The Scots sang:

"And it's ho! for the bonnets of bonny Dundee."

The Arcellæ sing:

"And it's ho! for the bonnets of bonny Dentatæ."

For the Arcellæ are just as proud of their headdresses as the Scots were, and consider them a sort of coat of arms by which each individual may proclaim to the world his title to a long line of distinguished ancestors.

I think the Arcellæ never go to war, but when they go abroad to display their clothes there is no doubt but the Accuminatæ think theirs is the most stylish and becoming hat; and the Dentatæ think theirs is; and the Mitratæ think *theirs* is; else why should they persist in wearing that particular kind and never changing to one of the other styles, since they have the making all in their own hands?

And it is no wonder they like their headdresses, for they are very pretty, and the poor

creature looks so sorry and dejected when he has outgrown his hat and has to crawl out and lie around unclothed till he can make another (Chart I, Fig. 5)!

III.

THE SUN ANIMALCULE.

(*Actinophrys sol.*)

If you blow soap bubbles from the end of a tube into the air, blowing carefully with frequent pauses, you may make, not a single bubble, but a ball of small bubbles.

Now, if you can imagine that out from this globe of bubbles, radiating in all directions, are spines as colorless as the bubbles themselves, and that every moment or two a large bubble bursts and then forms itself again, you will know how the *Actinophrys sol* looks.

It is called the sun animalcule because the rays from the ball make it look like the old pictures of the sun.

You can find it in your *jardinière* and everywhere in fresh water, where other microscopic animals live, but its favorite residence is on sphagnum or bog moss.

A large one is $\frac{1}{600}$ of an inch in diameter. It is very quiet and well behaved. It has a gently gliding or floating motion, and moves in

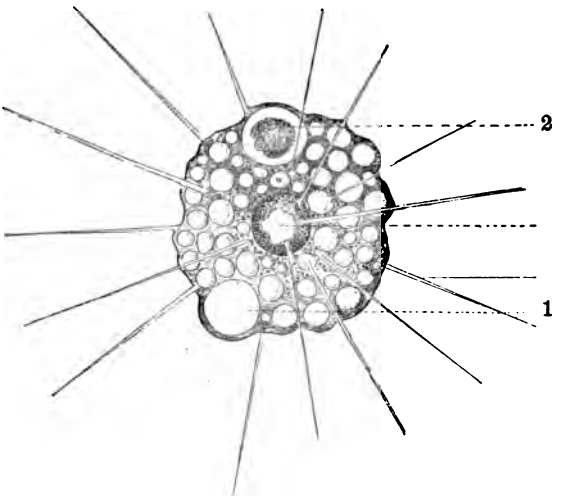


FIG. 6.—1, Pulsating vacuole; 2, food in food-vacuole.

a circular course when it moves at all. But it remains in one place for long periods of time.

It can travel, but seldom does. It can eat, but seldom does. It can withdraw its rays, and flatten itself like an amœba, but seldom does.

Although it remains so quiet that one has full opportunity for observing it, little is known of its life history. It is beautiful and nothing more; and so it lives, and nothing more, re-

minding one of the question the page put to Brutus's wife :

"What shall I do? Run to the Capitol, and nothing more?
And so return, and nothing more"?

But beauty to be really interesting must be coupled with energy and vivacity, and the sun animalcule has little of either.

Yet it is fond of society, and is often seen closely associated with others, their spines interlaced, the animacules piled in a heap, sometimes to the number of fifteen in one colony.

The actinophrys multiplies by division, and the colonies are made by successive divisions.

You will occasionally see some small animal entangled among the spines, struggling to get away. Sometimes it escapes; but when it does not it sticks fast to the adhesive ray that slowly retracts into the body of the sun animalcule, which forms a bubble or vacuole to encompass it. For the actinophrys, like the amœba, throws itself around its food and has no permanent mouth. If one ray is not enough to hold the struggling victim, other rays bend over to assist, and the poor creature is swallowed alive, and may be seen to squirm after it is inside its captor.

After partaking of food the animalcule be-

comes smoother in appearance, the bubbles becoming smaller and less prominent.

This actinophrys is devoid of organs of sense, circulation, respiration, or even digestion. Yet it measures its efforts by the necessity: One ray does the work if it can; if not, a second and third and fourth ray comes to its assistance.

Doesn't this look like an approach to intelligence?

But the senseless animal does other things which look as if it possessed not only sense but reason. Mr. Carter relates that an actinophrys was in a vessel where there were vegetable cells containing starch particles. One of the cells became ruptured, allowing a trifle of the contents to protrude through the crevice. The actinophrys came, extracted a starch grain, and crept to a distance to devour it. It then returned, extracting grains from the interior of the cell, always retiring with each grain, and returning again, as if it knew the way back and remembered where starch grains were to be found.

At another time Mr. Carter saw an actinophrys station itself close to the ripe spore cell of a plant, and when the cell burst and the young zoöspores came out, the actinophrys caught every one of them; retiring after the

last one was caught, as if instinctively conscious that no more remained.

The actinophrys is afraid of its cousin, the Mistress Amœba, and tries to avoid her, for the amœba tears off bits of the sun animalcule, devouring it piecemeal.

The *Vampyrella* looks like a reddish-yellow actinophrys, but it can withdraw and protrude its rays with greater celerity. It can pierce a spirogyra cell and extract its contents in five minutes, or can station itself outside the partition between two cells and suck the contents of both at once. It has been seen to devour the contents of seven cells at one meal, growing very portly in the operation. Probably because it sucks the life-blood of plants, it was named after the vampire, a bat which is supposed to suck the blood of animals and men.

When it has not eaten too much, the vampyrella can squeeze itself into an empty plant-cell and emerge in a long train, which gathers itself up again into a rounded body. When it reproduces, it "hatches" into three or four animals, which begin to protrude their rays before they are out of the shell or cyst.

IV.

(*Clathrulina elegans.*)

If you find one of these sun animalcules living in a glass house on the top of a glass stem, like a flower on a stalk, you may know it to be the *Clathrulina elegans.*

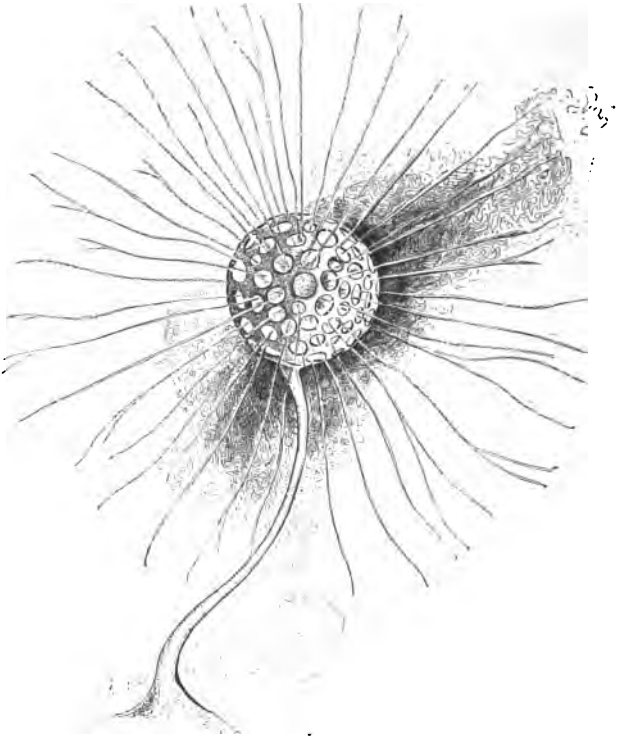


FIG. 7.—Clathrulina elegans.

The beautiful crystal house has many windows, through which the clathrulina protrudes fine rays, which act as arms. When hungry, it reaches out and brings its food in through the windows. It never uses these raylike pseudopodia for feet, because it has stretched out one into a stem, and has fastened itself so that it can travel no more.

This, and the actinophrys, the arcella, and the amœba are all called *rhizopods—rhizo*, meaning root; *pod*, meaning foot—because the pseudopodia of the arcella and amœba are like coarse, fleshy roots, and the rays of the two former are like fine, threadlike roots. But the clathrulina is the most truly "root-footed" of all, because it has transformed one of its rays into a genuine root stalk.

Both the sun animalcule and the clathrulina multiply by division. But the young clathrulina finds itself a prisoner in the beautiful glass house; and it says:

"I mean to make my escape *somehow*, and since there are no doors I'll just climb out at the window."

So out it goes, though it has to squeeze itself into a long string of colorless protoplasm in getting through.

But it soon rounds up into a ball of bub-

bles, and lives free like an actinophrys until it gets over its childish pranks, when it puts out a ray, takes root, and wanders no more.

You have heard of the man who founded his house on a rock, so that it withstood all the tempests, and of the one who founded his on sand, so that it washed away?

The clathrulina's house has a foundation less firm than the shifting sands, for it is built upon the fragile rootlets of the duckweed.

And the storms come and the floods rise and the waves beat vehemently upon that house, and it sways in the bayou, and sometimes it stands, but when it falls, great is the ruin thereof.

And when it begins to crack, the little clathrulina thinks an earthquake has come; and, though it never left its house before, it rushes out colorless and affrighted to die in the great watery highway, crushed amid the wreck and *débris* of the flood.

CHAPTER II.

THE WHIPLASHERS.

(*Flagellata.*)

I.

THERE are some little chaps in the green scum of the pools who ride along by simply flipping their whiplashes.

The whiplash is called a *flagellum* (which means whiplash), and the animals themselves are called Flagellata because they have the flagellum.

When one of them is going on a journey, it keeps the lash pointed ahead and thrown into curves or undulations, which pull against the water as a bird's wings do against the air, thus drawing the animal forward. The lash is exceedingly flexible, and when the creature is at rest the lash twists about, reaching back over or back under the body, as if searching for something it has lost, or guarding the body from the attack of some enemy.

One of the marine species, called *Noctiluca* (light of the night), shines at night like glowing phosphorus, making the sea look like

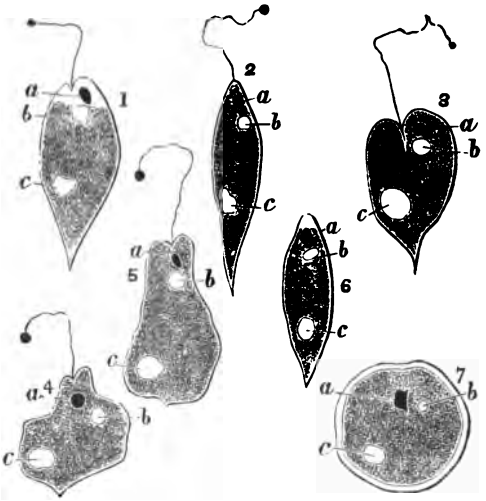


FIG. 8.—Various stages in the development of *Euglena viridis*: *a*, red eye spot; *b*, pulsating vacuole; *c*, nucleus; 7, preparing to form spores.

fire, and causing the superstitious sailors to feel eerie and grewsome.

This phosphorescence is a curious substitute that Nature has provided in the absence of other light; for down in the deep sea, living in the cold, dark waters where the rays of the sun can not penetrate, are myriads of creatures which are obliged to light their own path-

way by the phosphorescent lamps they carry with them, as men who work in dark mines light their way by lamps worn upon their caps.

The prettiest of the fresh-water species are the red and the green euglena, which look like slender willow leaves with the flagellum for a leaf stalk.

But you will know at once that the object at which you are looking is not a leaf, because it can change its course, and does not drift aimlessly, but has the movement of a creature which is *going somewhere.* So potent is will-power even in this incipient stage that it transforms this leaf from an inert *thing* into a purposeful *being.*

There is one species of these animals, probably the *Astasia,* which is colorless, and has a square, notched posterior, and a body so limber that it can be rolled back upon itself so as to resemble an irregular ball.

The *Euglena triqueta* is three-sided, and ends in a stiff point instead of a flagellum. Its body is not flexible, so it has to go tumbling along in the water like a leaf blown by the wind.

The red, or *Euglena sanguinea,* is bright crimson, and, when abundant, gives the water a reddish tinge.

The *Euglena viridis* is of a beautiful green color, with a crimson eye-spot near the base of the flagellum. When seen in shoals it makes the water appear green.

Both these varieties have flexible bodies. They double and twist as readily as the lash or filament; but when traveling they move smoothly, revolving on their long axes. They have pulsating vacuoles near the anterior border, and nuclei near the middle.

The green euglena retains its shape and color if it dries on the slide of the microscope, but the crimson eye-spot fades. When one of them becomes aged, since he has no hair to lose color by turning gray, he loses the color of his eye.

Have you noticed that this is the first semblance of an eye with which you have met among these microscopic animals? This is Nature's first experiment in eye-making, and it does not seem to be very successful, for this spot is not a true eye. It is probably no more than an organ which can distinguish light from darkness, as you, with closed eyes, can tell when you pass from shade into sunlight. It is the prophecy of an eye; for somehow, in the lower forms, Nature is always giving us a hint of what she is going to do by and by, just as,

in the higher forms, she is always recapitulating what she has already done, causing each higher animal, in the earliest period of its existence, to resemble various types of lower animals.

The Flagellata live in water, yet they can survive a long drought. When the water in the pond dries, they roll into a ball, as the amœba does when it receives a charge of electricity, and seem to exude a shell or coat as the cabbage worm does when it rests before changing into a butterfly.

These small creatures can endure more heat than man can. If the thermometer registers 112°, the papers are filled with accounts of sunstrokes. But the temperature must be 180° F. before the Euglena News can publish such items, and must be 70° higher still before the race becomes extinct and the last euglena man is dead; for the spores survive greater heat than the adults.

These Flagellata are getting up in the world as compared with the Amœbæ. The interior of their bodies, like that of the amœba, is a soft substance called *sarcode;* but they have a mouth which stays in one place at the base of the flagellum, so they always know where to find it—and *that*, you'll admit, is a great con-

venience; the flagellum is a permanent organ, which doesn't shrink back into the body; then, too, they have three or four ways of increasing their numbers:

1. They multiply by long division—i. e., by dividing along the length of the body—which process is called longitudinal fission. When they do this, the division begins in some of them by the division of the flagellum, which is an amusing process. They fasten it by the free end, and then wriggle or vibrate it until it splits into two shreds.

2. They multiply by short division—i. e., by dividing *across* the long axis. This is called transverse fission.

3. They break up into spores or *seeds* of animals (7, 8, Fig. 10).

When an animal is about to form spores, it withdraws all its organs of locomotion and prehension, becoming round and quiescent. The outer part becomes a sack or cyst, within which numerous small bodies form and grow until the cyst wall breaks and the spores or germs of new animals fly out.

This method of reproduction allies the animal with the plant.

II.

Some parents have a child's picture taken every year so as to keep a series of photographs which shall be a record of his changing features and growth through life.

Figs. 9 and 10 show a series of pictures, giving the life history of a flagellate monad whose name is *Dallingeria Drysdali.*

This is a wee little thing about $\frac{1}{4000}$ of an inch in length, which travels gracefully and

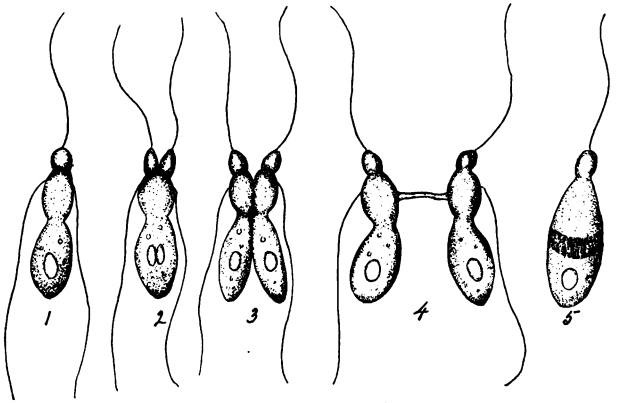


FIG. 9.—Dallingeria.

swiftly, ordinarily seeming very serious and demure.

But every little while it appears to feel the need of some gymnastic exercise. So it anchors

itself by the free ends of its posterior flagella, and, by coiling them up tight, draws itself back; then, by uncoiling, it suddenly springs forward; again it coils and draws back and again springs forward; repeating this jumping process over and over again, seeming to think it no end of fun.

The Dallingeria divides by longitudinal fission, splitting the anterior flagellum into two, in from one half to one minute. The whole process of division occupies not more than seven minutes, and is repeated at intervals of a few moments; so the Dallingeria need not be lonesome. If one boy tires and will not play the jumping game any longer, the other can make himself a new companion in seven minutes.

After repeated divisions of this sort our little monad makes a great departure from its ordinary customs of life.

Some of the individuals have changed their appearance by absorbing the two lateral flagella, enlarging the nucleus, and forming a granular band across the middle of the body (5, Fig. 9). One of these individuals comes swimming up to our little monad as it springs about coiling and uncoiling its flagella, and immediately the two love and wed and go

sailing out into the west together (6, Fig. 10).

In four or five hours the trailing flagella of the one and the anterior flagella and nuclei of

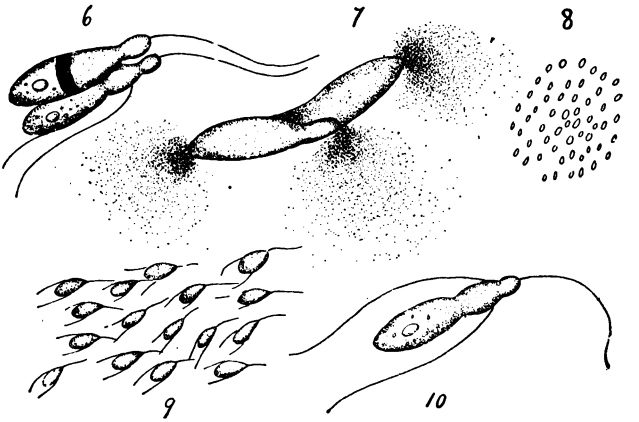


FIG. 10.—Dallingeria and family.

both have disappeared, the two are one, and look like a sack from which fine flour is issuing (7, Fig. 10). The particles of this fine flour increase in size until in about four hours they are seen to be perfectly formed flagellate monads (8, 9, 10, Fig. 10).

The godfathers of these little creatures, Messrs. Dallinger and Drysdale, after whom they are named and who first introduced them to the public, have, with true paternal fond-

ness, left many more photographs of them and a much fuller account of the incidents of their childhood than can be given here. But what has been given may fairly be taken as a brief genealogy of the old and distinguished Flagella Family.

CHAPTER III.

CILIATA.

You have seen the amœba traveling by means of pseudopodia; the arcella by means of pseudopods and miniature balloons; the sun animalcule by means of spines; and the Flagellata by means of delicate whiplashes.

The fish uses fins for feet; the tadpole, a posterior rudder; the leech uses suckers; the bird has wings to tread the air; the snake walks with its ribs, setting them forward alternately on either side as a boy does his feet; and when you come to the animal Man, he has a great variety of feet or organs of locomotion besides his two legs: for what is a sleigh, or a carriage, or a boat, or a bicycle, or a railroad car, but another kind of pseudopod which man has extemporized to expedite his progress? All these are locomotor pseudopodia invented to enable man to walk faster.

But of all the odd things which have been

used in traveling, there is nothing odder than that which we are about to investigate. It is nothing else than very short, fine hairs.

We are now to study a large class of animals, including the bell animalcule, paramœcium, stentor, vaginicola, and many more, which are all known as *Ciliata*, because they propel themselves by fanning the water with cilia or short hairs.

The Ciliata knew how to "feather" before man ever handled an oar, and they were the inventors of the "back stroke"; for many of them can travel backward as readily as forward by reversing the action of their cilia.

Some of them use cilia to assist in swallowing their food, having a funnel or œsophagus lined with hairs which carry the food down with the currents of water.

These animals are an advance upon the foregoing ones; for these all have a permanent mouth orifice, and a permanent place to eject waste food; their vacuoles are better developed; and some even have a dental armature or experiment in the direction of teeth.

Nature is beginning to differentiate or set aside portions of protoplasm for special uses, and to keep organs ready-made instead of having to make them every time they are needed.

Hence these Ciliata have a funnel always ready to receive food, and they keep hands to secure food and feet with which to travel always in stock, in the shape of cilia.

I.

(*Vorticellæ.*)

Men go fishing with flies and worms, but the Ciliates go fishing with these invisible hairs. And this is the way they do it: They keep these cilia falling down one after another in a circle. Round and round they go, dropping and picking themselves up again so fast that you can scarcely see them. This creates a whirlpool or vortex in the water, which catches the particles of food in its eddies, and carries them down the whirlpool into the little animal's throat. It is because they make this vortex that some are called *Vorticellæ.*

These are also called bell animalcules, because they are shaped like a bell, or a dainty china cup.

They are the dearest little creatures in the world—so shy, so pretty, so graceful, so charming. You are not a complete, all-around boy

or girl if you are not exceedingly pleased the first time you see a live bell animalcule.

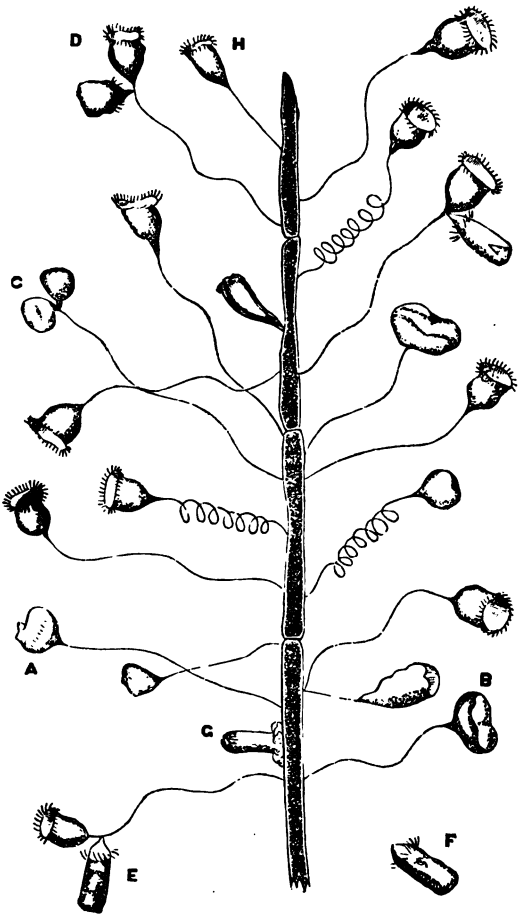


FIG. 11.—*Vorticella nebulifera*, showing development of individual stages A to F (E and F free).

Lift a slip of nasturtium from your *jardinière* and carefully clip off a rootlet. Put it on your slide with a drop of water, and you are likely to see a score of *Vorticellæ* attached to the root: some with their beautiful cups expanded at the end of long, thread-like stems; some with the stem coiled into a spiral, resting against the root.

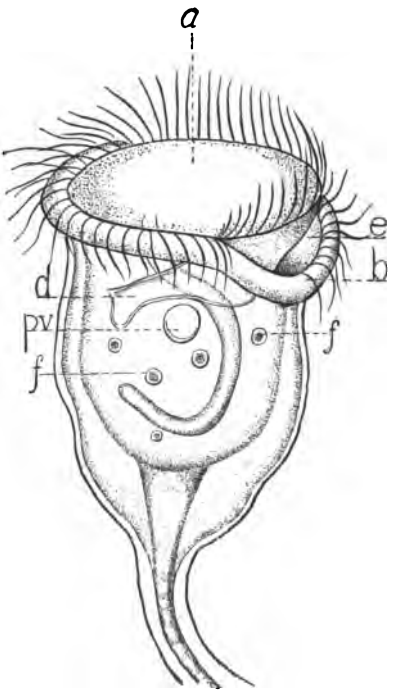


FIG. 12.—Bell animalcule: *a*, ciliated disk; *b*, rim or lip; *d*, œsophagus; *e*, funnel; *f*, food; *pv*, pulsating vacuole.

They are transparent and colorless except for the food balls; but you can see the cilia fanning the water to make the whirlpool, and you will notice that when mosses or small animals are caught in the outer waves they go around in a circle, sometimes making their escape when

they have made one circuit, and sometimes going round and round till they disappear in the funnel shown in Fig. 12.

From the funnel they go into the œsophagus, thence into the body; and when the nutriment is extracted they are thrown out again *at the funnel.*

If coloring matter enters the body it is excreted by the vacuole. A little carmine or aniline blue mixed with the water on the slide will make all these microscopic animals more beautiful, and will aid in discovering the operations which are carried on by the body.

Fig. 12 represents a bell animalcule six hundred times its natural size. Think of all this ciliating and swallowing, digesting and excreting going on in a creature only one six-hundredth the size of the picture—a creature too small and ethereal to be seen at all by the unaided eye!

Yet this minute being has the sense of touch developed to a remarkable degree, and when any other animal brushes against it even lightly, it disappears so suddenly that you wonder where it has gone, until you see it lifting the budshaped head from the mosses and timidly creeping out again.

When frightened it closes its house by

withdrawing the ciliary disk, folding the cilia in upon it, contracting the rim, and coiling the stem. But the whole thing is done in the twinkling of an eye. When the danger is

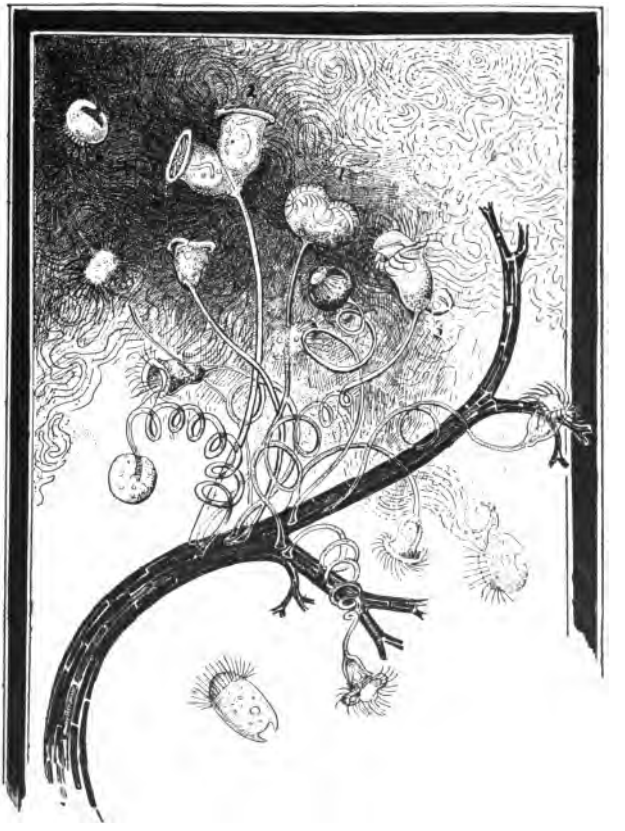


FIG. 13.—*Vorticellæ:* Dividing, budding, coiling, uncoiling, and free.

passed it reverses this order, unfolding again like a bud in the sunshine.

The stem of the vorticella contracts by means of a muscle situated in the interior of it, which responds instantly as if at the definite command of the will. This is the first pronounced case of differentiation of matter into muscular fiber.

The bell animalcule multiplies by longitudinal fission, as shown by Fig. 13. The whole animal parts down to the stem, one or both new animals floating away.

Another mode of reproduction among them is the putting out of little buds of animals (3, Fig. 13).

The vorticella does something which man is trying to imitate.

You read in the papers that a certain man in Illinois was going to die, or appear to die, and a crop of barley was to be raised on his grave. When the barley ripened his friends were to open the grave, and he was to waken from his trance and be alive again.

Another man, in Ohio, went into a hypnotic sleep and lay buried in a cellar for two months, at which time his friends dug him up and rubbed him into life; so said the Chicago Inter-Ocean.

You all know how Dr. Tanner lived forty days without food.

The vorticella can do all these and more. Whenever a famine comes in Vorticel-land the inhabitants close their houses, incase themselves in cysts, and remain unnourished indefinitely. Or when there comes a drought, and the water in the pools evaporates, the little creatures huddle together in the deepest hollows, eating and playing as happy as ever till the last drop is gone. Then they go into a trance or hypnotic sleep, lying in hypnocysts, parching in the hot sun for months. But when the rains come and the pond refills, out they all come trooping, as bright and lively as though they felt much refreshed, seeming to say by their actions, "Oh, it's a great lark to play Rip Van Winkle!"

Sometimes as they lie encysted in the dry bed of a pond, old Æolus, the wind giant, comes along and catches them up with the dust and bears them captive in his arms as he flies through space, depositing them at last on roofs to be carried into cisterns, or in horse troughs, or in eaves clogged with leaves, where they waken from their trances, come out of their cases, grow new stems, and begin to turn about in all directions, exploring the new world

in which they find themselves. And if they had eyes there is no doubt that in them would be that wondering look which is in the eyes of new babies as they turn their gaze about the

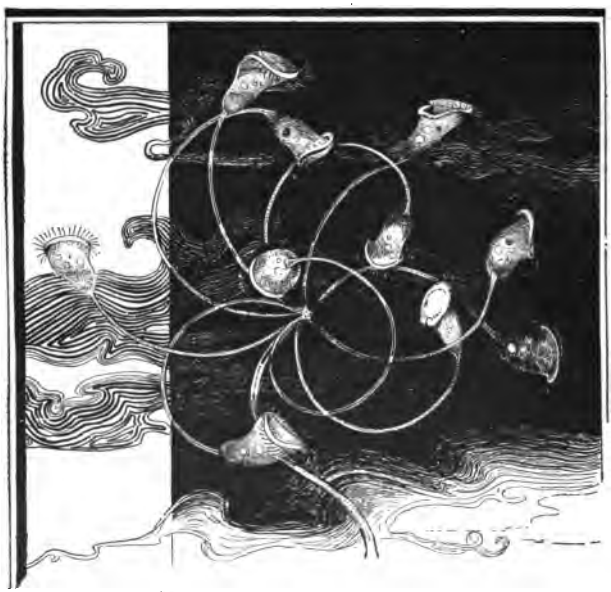


FIG. 14.—Animated calla-lilies.

four-walled world in which they lie puzzling over the strange environment into which they have come. And when you see these little bells you will smile at them as you do at the babies, and say: "Blessings on your little fuzzy heads! Where did you come from?"

There are known to be fifty varieties of Vorticellæ. Some live solitary, each on a stem of its own; others live in colonies or villages on branching treelike stems. In some of these the individual can close his house without alarming the rest of the village, or the entire community can close up at once. Others, as the epistylis, have a rigid stem, and only the individual can contract.

When these people live in colonies, you perceive that there must be something like co-operative housekeeping, for, though each does his own fishing, he must do it where the company is located. There are some colonies, as on Steamer No. 2, Ocean Line, where the empty stems seem to indicate that some wayward member of the family has broken his tether and has gone off to set up in business for himself.

Fig. 14 shows a colony of ten calla-lily-shaped beauties that I found fishing together. They at no time recoiled singly, but occasionally all sank at once in great precipitation upon the main stem.

After a while they decided that the fishing was poor, so they all massed together and emigrated to parts unknown.

Later they were found living in opulence

in a new country, and in an hour or two they had again colonized a new territory.

When one of the solitary Vorticellæ becomes tired of its dwelling place and desires to "go West and grow up with the country," it closes its house just as it does when frightened. Then it breaks camp—in rare instances carrying the stem with it, trailing through the water. But usually a second circle of cilia appears near the posterior or stem end, and the vorticella breaks loose, leaving the stem coiled and useless. Then it backs out and turns round, sailing with the posterior part foremost, just as you back a boat out and turn it around in order to row with the pointed end against the stream.

When it reaches the far country which, though the goal of its aspirations, is but a neighboring island of moss, it cuddles down into the moss, seeming to attach itself by this last band of cilia until it has time to grow a new stem.

Then the cilia appear at the other extremity, and what *was* the anterior part when attached before is again the anterior or mouth part of the body.

The books and the scientists say that when a bell animalcule is preparing to move, it "loses

its *anterior cilia and rim*, and develops posterior cilia; and that when it breaks away the anterior part becomes posterior and the mouth closes, *never to open again.*"

In other words, they would lead you to believe that when the vorticella moves it stands on its head till it moves again—that it is a sort of patent, reversible, double-action creature which can turn feet into head and head into feet at pleasure.

But the vorticella itself seems to have different ideas of things, and protests against the statement that it "loses its rim and anterior cilia"; 1, 1′, 1′, Fig. 15, shows one of them in three stages of preparation for travel. 2, shows one traveling *with both circles* of cilia present, the scientists to the contrary notwithstanding.

The same Fig., 3, 3′, 3″, 3‴, shows one which rowed up to some moss, attached itself, and, within two hours and a half, grew a stem twice its length, and displayed the posterior cilia again as if prepared to begin its migrations anew. So, if it really stood on its head the second time it was attached, it was only two hours and a half before it turned another somersault and opened its first mouth again.

Now, No. 2 or No. 3 is a frail and delicate



FIG. 15.—Vorticellæ.

creature, and a scientist is a great and powerful man; but if No. 2 or No. 3 chooses to enter into a contest with the great scientist, you may

be sure the little one will come out ahead. That's a way of little bodies whose mouths can't be closed.

And if, as I suspect, the Vorticellæ have decided to have an anterior or prehensile band of cilia and also a posterior or locomotor band, and to keep the cilia concealed or absorbed into the body like true pseudopodia when not in use—if they have decided to do this, they'll do it; and it's useless for the scientists to argue the matter with them. They will go right along having their own way, looking so sweet and amiable and playing so gracefully that you will never know their pretty ways are only a cloak to hide a deep-laid plot to confound the scientists.

As the bell animalcule sails free, it assumes a great variety of shapes, some of which are only apparent ones, caused by its rolling over in the water and presenting different sides to view. Sometimes it seems round; sometimes almost square; sometimes it looks like a basin or kettle; and sometimes like an old-fashioned entailed hat.

They keep up a lively fanning of the water with their cilia as they travel.

But some of them are too cute to work their own laborious passage in this way. Those,

especially, who live in colonies on branched stems like to travel far and fast; so they attach themselves to some larger animal which is a swift sailer, like a cyclops or the larva of

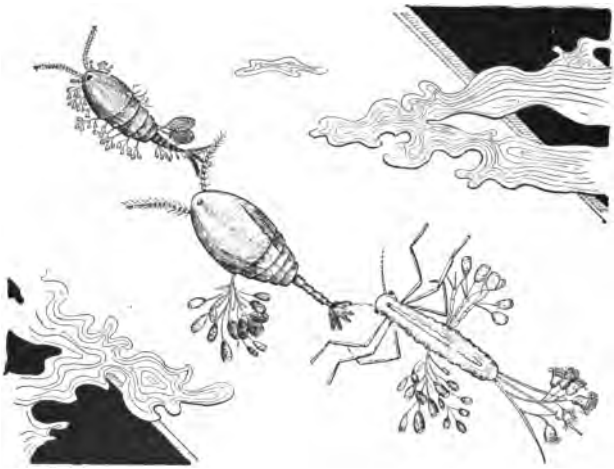


FIG. 16.—Ocean-steamer line.

some insect, and are thus transported without effort on their part.

You see they had their ocean-steamer lines and Great Easterns long before we had.

Can you hear them sing as they sail—

> Oh, a life on the ocean wave,
> A home on the rolling deep?

II.

IN A GOBLET.

(*Vaginicola.*)

There are some of the Ciliata that live in crystal vases. These vases are longer than those of the bell animalcule, and the animal within is very elastic and can extend itself to twice the length of its inclosing case or house;

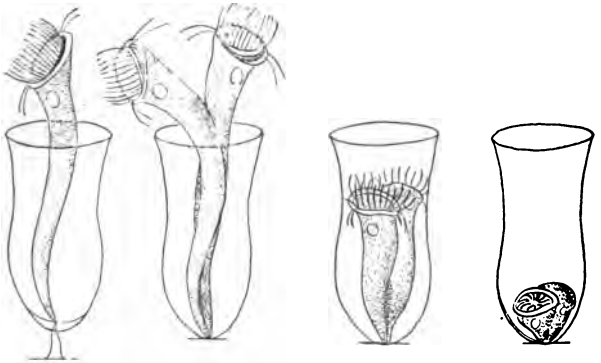


FIG. 17.—1, *Cothurnia*; 2, 3, 4, *Vaginicolæ*.

or it can contract so as to lie at the bottom of the vase.

These are the *Vaginicola* and *Cothurnia*. The vase in which they live is called a *lorica*. They are attached only at the bottom of the

lorica, being free on the sides. Both they and the lorica are transparent; and the only way in which you can distinguish the vaginicola from the cothurnia is that the vase of the former is sessile while that of the latter is attached by a short stem, and is sometimes tinged with brown.

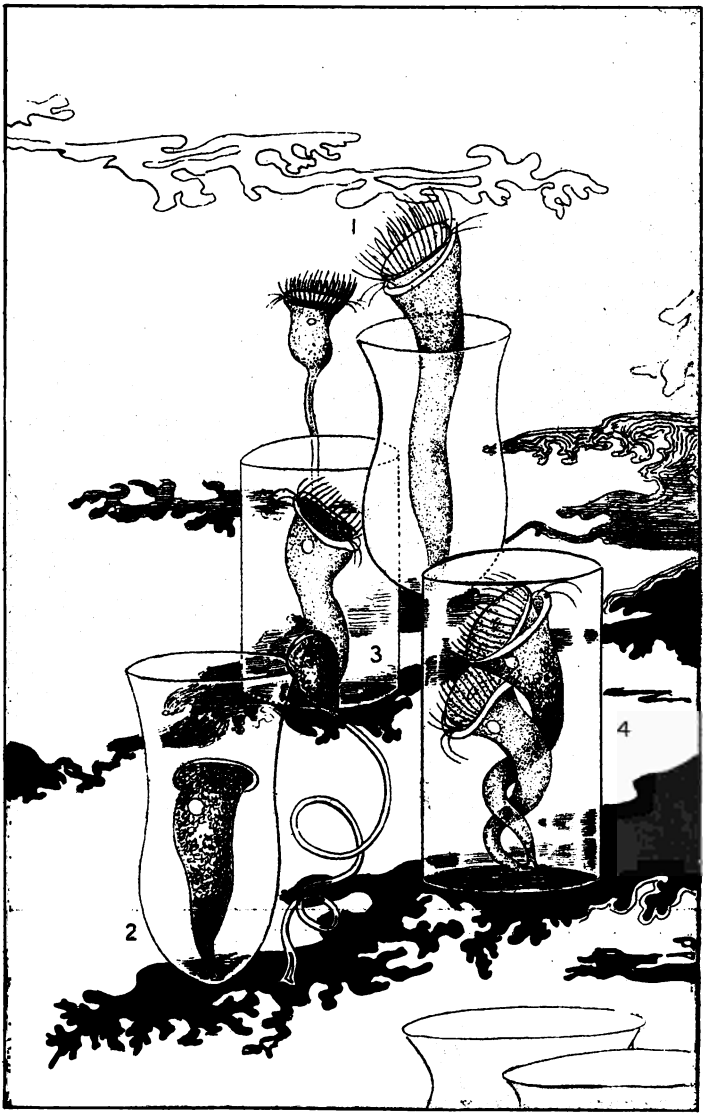
When the cothurnia is frightened it *tips its house over*, by bending the stem or pedicle, at the same time that it contracts into it to escape the danger.

Both these animals are of much the same nature as the bell animalcule. They are transparent, have pulsating vacuoles and crown of cilia, and procure food in the same manner by creating currents in the water. The chief difference is that these can stretch like rubber and the bell animalcule can not; and these look like flowers in a vase instead of flowers on a stem.

They do not need to leave their houses to procure food. They can sit at their doors and fish, or can even remain halfway down in the lorica and produce the currents and secure the food.

Two animals often live in one case, and look very cunning, fishing together or cuddling on the floor of their house; for they can be distinctly seen through the lorica.

CHART II



Vaginicola

You may watch them gradually lengthen their bodies until they lean far out over the top of the vase, in their eagerness to secure choice morsels. Then, when they are thus extended, if you tap the slide, they will spring back and hide in the bottom of the vase, trying to make believe they are not at home.

They are like the two little children left in charge of the house, who scampered under the bed when a stranger tapped at the door, and who, when he rapped again, timidly sang out, "We're all gone!"

I have seen a bell animalcule and a vaginicola play Pussy-wants-a-corner (1, 2, Chart II).

The former was anchored near the latter in such position that every time it recoiled on its stem it hit against the vaginicola's house, causing it to recoil also. When the bell animalcule uncoiled and set its whirlpool in motion again, out would come the vaginicola and set its whirlpool going, which jarred and alarmed the bell animalcule. Back it would spring, tapping at the vaginicola's door on the way, and under the bed the vaginicola would dart. Thus they kept going, each probably thinking the other very rude to plague it in that way, when all it wanted was to attend quietly to its own fishing without molesting anybody.

The young of the *Vaginicolæ* come from true buds and swim about freely for awhile, settling down at length and forming a lorica in which to dwell; for, like the arcella and clathrulina, they have to build their own dwellings. Animals, you see, are like people: some are "born with a silver spoon in their mouths"—that is, with a fortune already provided; and some are born destitute and are obliged to take care of themselves and build their own houses.

If you examine minutely all the members of the vaginicolan family you may spy out one of Nature's secrets which she never breathed to anybody until long after she made these protozoans. You have already noticed that Nature was beginning to make loricas, into which the animals could retreat in times of danger. Now the secret you may discover is that she already had in mind a strong, hard house, like the snail's, into which the owner could withdraw, *closing the door behind him* to bar out intruders; and, while she was working among these *Vaginicolæ*, she was experimenting on just such a house as this. You will find the snail's house closed securely by the horny operculum he draws into the opening; and the *Pyxicola* has a similar operculum to close his vase. Attached to the side of its lorica the *Thuricola* has a valve

which closes when the animal shrinks down into its case, as the lid closes over the nest of the trapdoor spider. Think of spiders and pro-

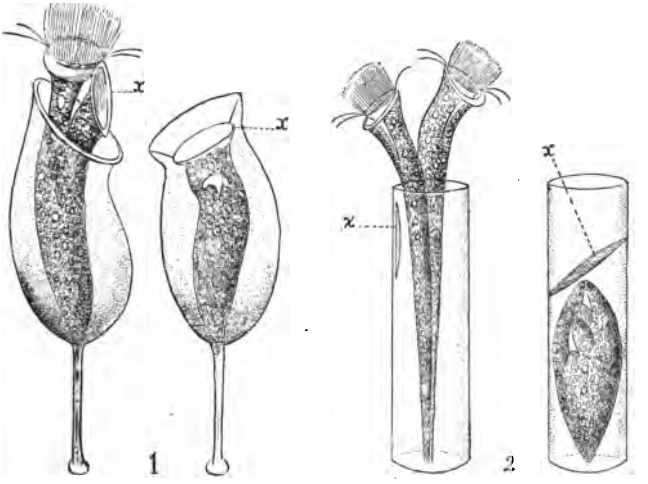


Fig. 18.—1, *Pyxicola;* 2, *Thuricola.*

tozoans having actual doors which swing on hinges!

Who knows of what else beside spiders and snails Nature was thinking when she made the thuricola? She may have been revolving in her mind schemes concerning an animal called *Man*, who should have a lorica of brick or stone with an electric bell to ring open the valve.

But we are prying too far into Nature's

plans, and must go back into the protozoan world where she is at work, and where one morning No. 3, Chart II, appeared on the stage of action, in a beautiful crystal case. An hour later, tired of single blessedness, it had changed into 4,—two twisted together with cilia playing.

After a time they extended themselves beyond the lorica, making great whirlpools. A diatom gently sailing that way was caught in the current and carried round and round for fifteen minutes, now in wide, now in narrow circles, now fast, now slow. His little electric launch had a hard time with the buffeting waves. When he at length escaped, he settled down in a clump of reeds, "quite chapfallen."

He seemed to be reciting poetry, and to be saying:

We have had enough of action, and of motion we,
Rolled to starboard, rolled to larboard, when the surge was seething free,
Where the wallowing monster spouted his foam fountains in the sea.
Death is the end of life; ah! why should life all labor be?
Let us alone. Is there any peace
In ever climbing up the climbing wave?
All things have rest. Let us alone.

Presently a little brilliantly green, transparent paramœcium, scurrying merrily along, fell into

this same vaginicolan Charybdis. He struggled bravely for awhile, and after many giddy revolutions was cast upon a reef of vegetation, utterly worn and fagged with the battle of life.

He merrily scurried no more; and his reasons for no longer exerting himself were the same that Brer Jeems's wife gave for his not sawing Brer Remus's wood:

"Hope you'll 'scuse Jeems," she said. "He can't ver' well wuk to-day. Fust place, he got no time; second place, he doan feel fust-rate dis mawnin'; third place, he's *dade*."

III.

THE TRUMPET ANIMALCULE.

(*Stentor.*)

If you try to get a snap shot with your kodak at a trumpet animalcule, you will obtain such a variety of photographs as will seem to represent a score of different creatures instead of a single one. Fig. 19 gives a collection of photographs of these animals, taken with a pencil. The *Stentor* lives either solitary or in colonies. At times, when attached, it twists on its stem, looking like a half-filled balloon swaying about

and tugging at its ropes, wrinkled and grooved at the bottom. There are cilia distributed over the whole body of the stentor, but in some of



FIG. 19.—Colony of stentors.

these figures (2, 3) you will notice a cluster of cilia which at times appears external, at other times internal. This cluster is the budding head of a young stentor; for the pulsating

vacuole divides and the mouth and throat of the offspring appear before there is any sign of division in the parent. This is another case of transverse fission. The mouth of the new creature appears about halfway down the tube of the old one. When the division is complete, both swim away smaller in size, resembling an elongated bell animalcule. Two hours are occupied in this process of multiplication.

The disk of some stentors looks like a ripe sunflower with the seeds removed. The rim or lip around the disk seems to be so flexible that they can "pout their lips" and "make mouths."

The indigestible food is expelled from the mouth or funnel. Occasionally one of them tries to swallow an object larger than its throat, and, after repeated efforts, is obliged to relinquish the undertaking and eject the whole mass.

A stentor has lived for three days under a cover glass, surrounded with tallow to prevent evaporation of the water, and has seemed to enjoy his walled fortress.

They usually contract to avoid danger; but sometimes they fall over and lie at full length till the disturbance has passed. They are not as timid as the vaginicola, and pay no attention when you tap the slide. Do you suppose that

is because the vaginicola can hear, and the stentor is deaf?

Some of the stentors are always rovers; others remain for life attached to one place; while still others are able to attach and free themselves at pleasure. These latter take a homestead and live there as long as they like the climate and the neighbors, and when they are no longer pleased they pull up stakes and move along, pre-empting another claim.

It must be admitted that the stentors are not very graceful; neither have they fine figures; but they try to remedy these defects by wearing delicate red, blue, green, brown, black, and amber color.

It would scarcely be expected that a creature which is itself microscopic would be found to have still smaller animals parasitic upon it, but the stentor furnishes food and home to numerous beings which were at first supposed to be its children, but which are of alien blood. The same is true of nearly every animal we shall find in the bayou, from the comparatively hardy cyclops to the ethereal bell animalcule.

IV.

LIVING SLIPPERS.

(*Paramœcium.*)

If you place a dead clam or a bit of beefsteak in water and keep it in a warm place for a day or two, the water will be swarming with minute white specks in constant motion. They are barely visible when held to the light in a glass dish. They are the *Paramœcium caudatum*, which looks flat, though it is slightly con-

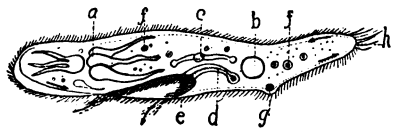


FIG. 20.—*Paramœcium: a*, vacuole distributing secretion; *b*, vacuole filling; *c*, nucleus; *d*, œsophagus; *e*, funnel; *f*, food balls; *g*, temporary anus.

vex on the back, and which has but one vacuole; and the *Paramœcium aurelia*, which is somewhat prismatic or three-sided, and has two pulsatile vacuoles that close alternately. These animals may be found in your nasturtium vase, or they may be bred in smaller numbers in water in which hay or any vegetable matter is decomposing; but they are larger and more

numerous in water containing meat; and clam soup is their favorite diet.

When found in water rich in decaying vegetable matter they are full of green and reddish food, and the richness of their color is proportionate to the richness of their pasture. Usually they are almost colorless, and some species are so diminutive that under a high magnifying power they look no larger than a small pansy seed. Those which appear to the naked eye as minute white specks seem almost two inches long when under an ordinary school microscope.

The aurelia is often called the slipper animalcule because it resembles a moccasin or low slipper badly run down at the heel. The opening in the slipper for the entrance of the foot is, in the paramœcium, the funnel leading to the œsophagus, and is lined with cilia which fan the water to bring particles of food into the funnel. The food of many of these ciliates is made into balls before it leaves the œsophagus and enters the sarcode or soft substance, through which it makes a circuit of the body before the waste portion is ejected. Owing to the numerous vacuoles formed around the food balls, the ciliates have been called the "polygastria," or many-stomached. There are peo-

ple that live to eat, who must envy these creatures their numerous stomachs.

The hairs which line the funnel are the prehensile cilia, since they take the place of hands in securing food. The locomotor cilia are distributed over the whole surface of the body, acting as oars and propelling the animal like an ancient galley manned by a hundred rowers. Many an unwary victim sliding down the funnel throat, gets a free ride, like Jonah, but finds itself in a dangerous craft and one likely to capsize, for the paramœcium often sets out with a long, rolling motion, taking a spiral course through the water.

The paramœcium is cosmopolitan in habit, living in all waters and accommodating itself to a great variety of conditions.

The nucleus is club-shaped, and when single is located near the center; when there are two they are located near the extremities. The same is true of the pulsating vacuoles. The vacuole is a rudimentary heart, whose purpose, like that of other hearts, is the circulation of the fluid secreted. A heart, you know, is a pumping machine, with pipes so laid as to irrigate every part of the body.

Paramœcii can bend and twist their bodies, and often amuse themselves by rolling over

and over with a swift, graceful motion. At other times they anchor or attach themselves by one extremity, moving the other around in a circle.

Sometimes they gambol about in the water, disporting themselves like seals in the tanks at the parks.

The space between the slide and the cover glass used with a microscope is very small, yet it is sufficient to admit three layers of these animals. In their gambols it occasionally happens that at the same time one darts under and another over the back of a third without disturbing it.

The paramœcium is soft and slightly elastic, and can squeeze through channels among the mosses, which are narrower than its body.

The bits of moss are islands and continents to little things like slipper animalcules. They go in and out, exploring the bays and rounding the capes as if they had a curiosity about them, or intended making an atlas of them. Sometimes you may see a long line of these live slippers, each resting its toe on the coast of a moss continent, the whole looking like a row of canoes drawn up along a beach.

The paramœcium can endure an astonish-

ing degree of cold. Both it and the bell animalcule may be found in water which has been gently stirred until it is thickened with flakes of ice. But if the water remains quiet until it becomes solid ice, and is then thawed, the animals will have disappeared.

Sometimes a paramœcium becomes weary of living alone and seeks a mate, by whose side

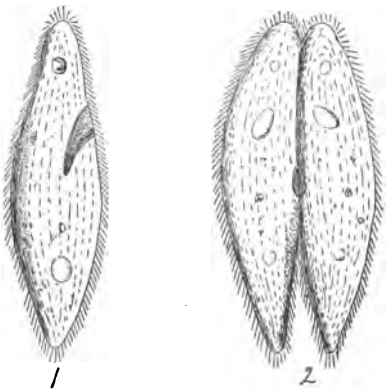


FIG. 21.—Conjugation.

it lives in such close companionship that the twain are made one and remain a single animal, either for an indefinite period or for evermore. This is called conjugation, and is a custom among all the Ciliata (1 and 2, Fig. 21).

The *Chilodon cucullulus* multiplies by both longitudinal and transverse fission. These little

creatures roll and rush about in a very amusing manner, and the two kinds of division might be considered an optical illusion, except for the fact that while the normal animal has but one pulsating vacuole, when it comes to divide, two pulsating vacuoles appear,—near the attached ends in those that divide transversely, and near the free ends of those that divide longitudinally.

The paramœcium's ordinary method of making two out of one is by transverse fission; and so rapid is this process, and so often repeated, that it has been computed that one paramœcium may become the progenitor of 1,364,000 in forty-two days.

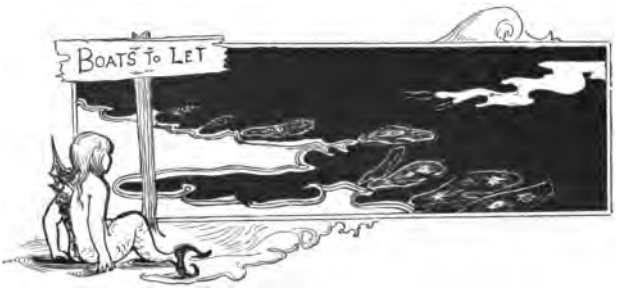
Now, what a fortunate thing it is that the original paramœcium is eliminated—all used up—in the production of the children!

If old Mother P. had to live on and take care of all the 1,364,000 children, she'd be more distracted than the old woman who lived in a shoe, and had so many children she didn't know what to do,—especially if she happened to have a kind-hearted neighbor like the one who gave each of her friend's five boys a tin horn for a Christmas present.

Little wonder that the paramœcium's soliloquy runs thus:

To be, or not to be, is not the question.
'Tis better not endure the one million three hundred and sixty-four thousand natural shocks
That flesh is heir to.
One million three hundred and sixty-four thousand tin horns! There's the respect
That makes calamity a long life.
I'll rather end the ills I have
Than fly to others that I know not of.

And she shows admirable discretion.



V.

SWAN'S NECK.

(*Trachelocerca olor.*)

The *Trachelocerca olor* is like a paramœcium with an extensile neck which can be protruded ten or twelve times the length of the body or can be entirely withdrawn into it. You will wonder how so much neck can be contained in so little body.

The trachelocerca is called the swan's neck, because the curvings of its long throat suggest those of the swan's. But sometimes it doubles its neck around in a manner to suggest the writhing of a serpent rather than the grace of a swan; and when you see it darting its head about in the water with a motion

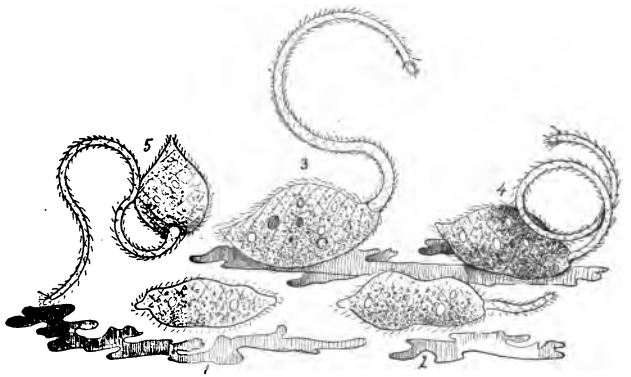


FIG. 22.—Trachelocerca.

like that of a fowl picking up food, seemingly trying to tie its throat into a knot, you are likely to say to it "You little goose," instead of "You lovely swan."

Sometimes the neck seems to be a proboscis to seize food; sometimes a spy searching out the land and saying, "Where does my way lie?" Sometimes it seems to be a general information bureau, gathering facts about the

outlying country; or perhaps a bodyguard, looking before, behind, and around in all directions for any foe who may be lurking near. At other times it is a pilot standing at his post and steering true to the line, as the trachelocerca steadily follows its course in a clear sea.

The trachelocerca is colorless, has one pulsating vacuole, and its nucleus is so finely divided as to look like powder scattered through the body. It can be detected only by using aniline; the nucleus always remaining uncolored. Previous to reproduction this powder-like nucleus gathers into a solid one, but after fission the nuclei of both individuals break into small particles and disperse as before. When swimming, it usually carries the neck foremost, but it can "back water" like the other Ciliata. The body can be contracted into almost spherical shape, or it can be greatly elongated at pleasure; and you will envy it this faculty, for, if a boy's body were elastic he could stretch it up to reach those apples that hang too high, or contract it so that his hands and feet would not protrude so far beyond his last year's suit of clothes.

A gentleman, who watched a trachelocerca dividing, says that it withdrew the neck and remained quiet for some time, except for a

ciliary action about the orifice for the neck, and an occasional brief protrusion of the proboscis. The animal appeared irregular and lumpy in outline. Then there appeared a line of constriction around the middle of the body, and presently the two halves were loosened so as to slide freely on each other. Once the anterior half threw out its neck and bobbed it about for a moment; then the head of the animal seemed to shift around to the side, at right angles to its former position, while a ciliary wreath appeared in corresponding position on the posterior half or new animal. This gave the two the appearance of having divided by longitudinal fission, whereas it was by true transverse fission. About an hour and a half after the first appearance of the constriction, the new animal threw out its neck to a great length and writhed it about with the utmost agility, sometimes completely encircling the body. The young one remained in contact with its parent, which again protruded its neck in the same manner. Then both were quiet. Again both threw out their necks and again dozed off to sleep.

VI.

(*Amphileptus.*)

There is another creature which closely resembles the swan's neck except that it is quite sharply pointed at both extremities and has several pulsating vacuoles arranged in a row along the side of its body. It is covered with fine cilia like the paramœcium, but is larger, measuring about one sixteenth of an inch. It is not so lively as the trachelocerca, being quiet and dignified in its movements. It can travel backward or forward with equal facility, as most of the ciliata can, since, using cilia for oars, all it has to do is to work the cilia in the opposite direction, or reverse the engine. The animal being covered with longitudinal rows of cilia has a slightly grooved appearance when it raises its neck so as to give an oblique view.

In most animals we find the head surmounting the neck; but if you look for that in the *Amphileptus*, you will be disappointed, for the proboscis terminates in a flat disk, and the mouth or swallowing tube is located at one side, below the neck,—that is, the mouth is in its shoulder, and the neck is used as the

elephant uses his proboscis, to convey food to the mouth.

The amphileptus is supposed to be one of the transverse fission class, but No. 3, Fig. 23, seems to be contrary-minded. These two were so closely attached along the entire length of

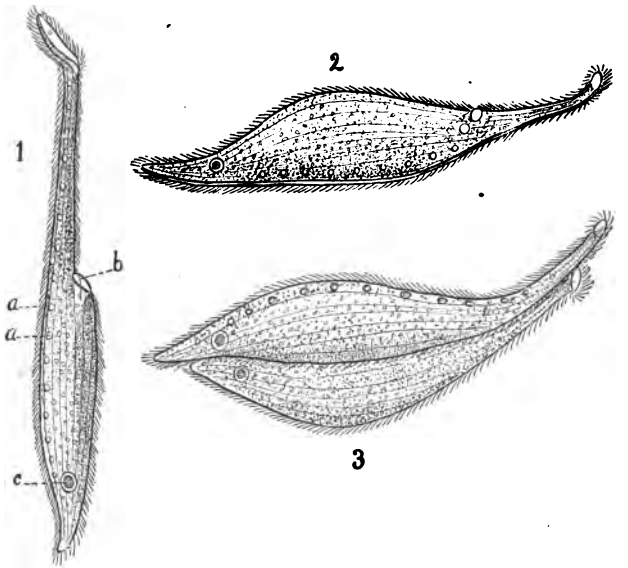
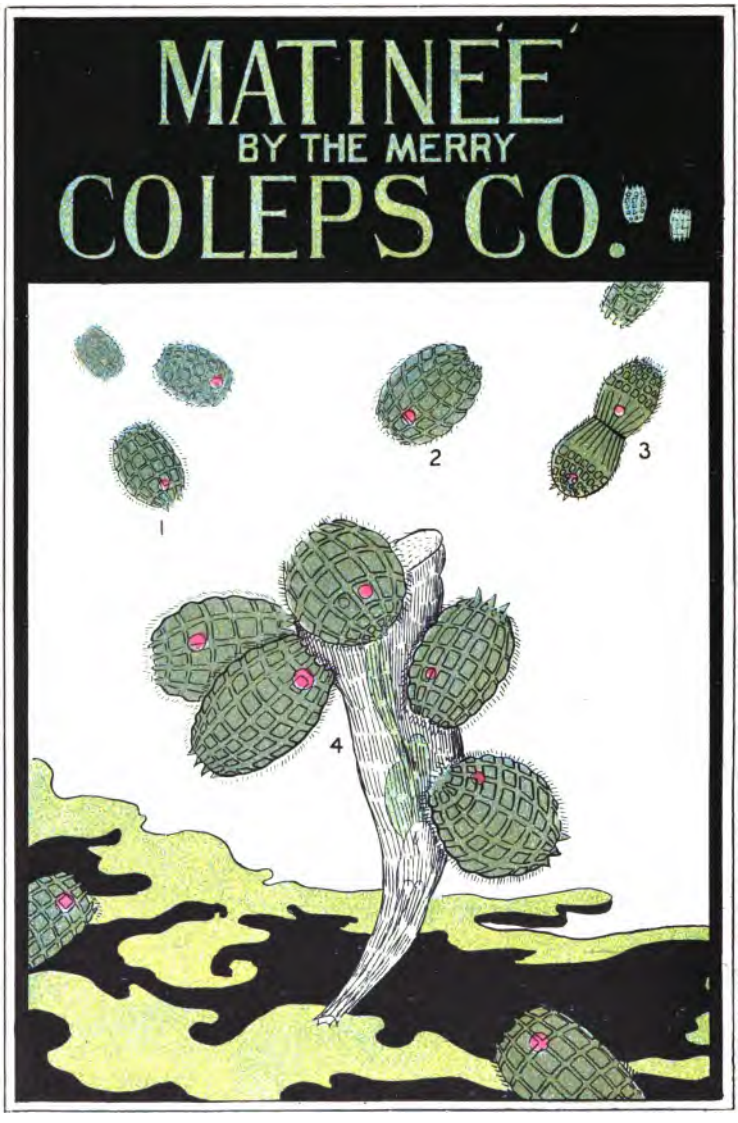


FIG. 23.—Amphileptus.

their bodies that when the large one raised its proboscis the little one's neck moved with it. It seems hardly probable that two animals which had once been separated could

CHART III.



ever unite so completely as to act with one mind.

If they do divide transversely the two parts must slide upon each other, or the neck and mouth of the old one must have the same migratory habit as the trachelocerca's.

There is a species of amphileptus in which the vacuoles are arranged in two series, one on either side of the body.

You remember that in the aurelia the two vacuoles contracted alternately? In this amphileptus the contraction runs from the anterior to the posterior part first on one side and then on the other. This alternation of motion along the two sides is interesting because it is the beginning of just such motion as we see in man when he walks. So here, again, we have surprised another of Nature's schemes long before she made it public.

VII.

THE JOLLY NAIL KEG.

(*Coleps.*)

Sometimes you will see little green-black or brown-black kegs with narrow staves and sunken hoops, rolling about in the water or careen-

ing over and over without changing place, with such velocity that it is impossible to tell what shape or manner of being you are looking upon. When you twirl a spool on a string or spin a top, you can distinguish nothing except the circular movement. So, when the little keg twirls rapidly you can distinguish nothing but revolution on an axis, and you feel sure it must have a string on one end and be anchored to the stick or moss near by. It seems to be tugging hard at its anchor.

This is the little *Coleps*. And he is a merry little fellow, eternally rolling and rolling. That is the business of life, he thinks; and almost the only time he pauses in his mad career is when he divides, as in 3, Chart III, or when he eats; and then he seems in haste to get through and go to twirling again.

Once a rotifer was crushed by the cover glass, and presently coleps began to assemble from all directions, as if scenting the prey from afar. They gathered around the rotifer, sucking the juice and distending their sides with feasting on so much richness, "swelling wisibly before my wery eyes," as old Weller said. While the little keg-shaped things were thus engaged, one could distinguish their toothed extremities, their sunken hoops, their

longitudinal lines or staves, their general color, and their red eye-spot.

As soon as their appetites were satisfied, away they went, careening about as though that was the one thing the doing of which could not be postponed.

Apparently the coleps's sole idea of happiness is to roll over in the water. Or perhaps that is its idea of usefulness. We all have such different ideas as to what is the really necessary thing to be done in life! And sometimes it seems as though the little coleps had figured it down as fine as the rest of us, who work with all our might and exert all our strength in turning around in one spot and accomplishing nothing of consequence. Perhaps to the eye of Omniscience we men and women, boys and girls, are only dusky little barrels, forever rolling, rolling—doing nothing. Possibly the busy coleps thinks its work of immense importance, and expects after a life well spent to receive the reward: "Well done, thou good and faithful servant; thou hast been faithful in rolling, I will make thee Master of High and Lofty Tumbling."

VIII.

(*Euplotes.*)

We have seen some little busybodies running along the stems of spirogyra, or the roots of duckweed on the slide, smelling along like mice, and, like mice, halting suddenly, taking a step backward, as though in search of some-

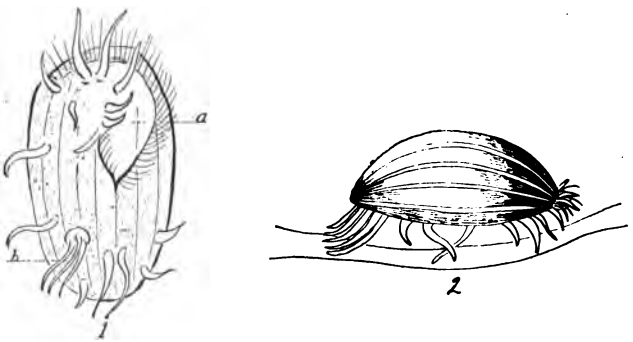


FIG. 24.—1, *Euplotes harpa;* 2, *Euplotes charon.*

thing of delicious odor over which they had passed in their haste; for they seem to have a well-developed sense of smell, and to be the first animal with true olfactory organs. When you get a side view of them you can see their humped-up backs and the swift movements of their legs.

In this position they somewhat resemble the wood armadillo—that gray, many-legged isopod which you find under boards on the ground.

The family name of these creatures is *Euplotes charon*, and you will be glad to make their acquaintance, I am sure; for this is the first of these microscopic animals which you know to have anterior and posterior ciliate processes or legs—to set one foot ahead of another, and to actually *walk*.

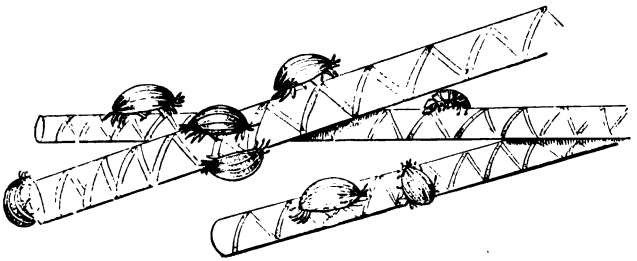
It is a comical little body, as it scampers out of sight under the decaying vegetation, or runs nibbling along it.

The legs are large, stiff, ciliate spines, and are attached to the body by true joints or articulations, for the animal can walk or run either backward or forward. The *Euplotes* did a good thing when it got a leg which need not be made every time it was wanted. A permanent leg was a great labor-saving device.

The *Euplotes striatus* resembles minute, transparent lilies of the valley gathered into a ball, rolling through the water as an animated crystal sphere.

The *E. harpa* is a much larger and more imposing animal, with an important and mas-

terful air as it journeys onward. When it swims on its back, as it usually does, you can plainly see the band of large cilia extending to the middle of the body, and the coarse spines or leglike cilia, part of which turn backward, part forward.



CHAPTER IV.

PROTOZOAN PHILOSOPHY.

ONE day a little bell animalcule was floating listlessly in the water, its ciliated disk withdrawn, its head drooping on its stem, looking very hopeless and disconsolate. It did not care for food; it did not seem to be glad that the day was bright and beautiful, and that the water glistened with the sunbeams that shone upon it; it did not even recoil as usual, in modest fear when a big Paramœcium came along; it did not seem to care whether he ate it or not.

"Why, what's the matter, little Belle?" asked the Paramœcium. "You look so forlorn, and don't seem to care to live any longer."

"I don't know as I do," said the Vorticella sadly. "Indeed, I don't know that I *am* alive. I don't think I ever *have been*. And it just makes me feel like crying to think of it."

"Why, here you are, a whole pretty little sweetheart; so what is there for you to grieve about?" asked the Paramœcium cheerfully.

"Why, you see it is this way," said Belle. "My mother divided into two to make me, and so I'm my own mother, and there isn't any me. And my mother was half of my grandmother, and so I'm my own grandmother. I don't see where there is room for any 'me' about me."

The Paramœcium drew nearer and said in a confidential whisper: "I don't mind telling *you*, Belle, that I've always been puzzled by that same question, for the same thing is true of me. But I always thought it best to keep a stiff upper lip, and to act bold and confident, so people wouldn't suspect that I wasn't anybody."

"Yes, I knew it was true of you, too, or I'd never have had the courage to speak to you about it. Only yesterday I saw one of your family break in two crosswise. Our family divide from the top down lengthwise. But I knew that, lengthwise or crosswise, it must amount to the same thing. And to see it done right here before my very eyes, and those two ends of a Paramœcium start off as though they really thought they were somebody, when neither one was anything in this weary world

but the half of its own mother—to see all this brought my own trouble home to me so forcibly that I couldn't sleep all night for thinking of it. It breaks my heart to think of us all being just ½ mother, ¼ grandmother, ⅛ great-grandmother, and probably not ourselves at all."

At this point a Swan's Neck, who had been watching them from an island across the channel, came gliding up in her soft, insinuating manner and said:

"Dear friends, I hope I am not intruding, but I think I can guess the subject of your conversation."

"Oh, you're quite welcome, Trache; and if you guess right, we'll tell you," said the Paramœcium.

"You know I go about the world a great deal more than you do, Belle," said the Swan's Neck, "and, walking so noiselessly, I often come upon people with their heads together, and they are always talking of one thing. The one great question which occupies the minds of all thoughtful Vorticellæ, Paramœcii, Amœbæ—of all people of whatever color, green or red or yellow or white, of every nationality—is this same one which you are discussing, viz., 'Have we any individual existence, or are we merely

the sum of our ancestors, the product of heredity?'"

"Now, if they are all puzzling about it, why not call a meeting and see if, by putting all our heads together at once, we can not come at the truth of the matter?" said the Paramœcium.

"Well, suppose we go and invite each tribe to send its best philosophers to discuss the question?" said the Swan's Neck.

"Yes, and let's invite the mathematicians too, for it is really a question of division and multiplication," said the Paramœcium, who prided himself on belonging to a family which could perform 1,364,000 divisions in forty-two days.

But the Vorticella said: "I think I'll not go with you to issue the invitations. I've sometimes broken loose, taking my stem with me, and sometimes have left it and have gone alone when I wished to cross the water to reside. But I feel so discouraged now that I don't believe I'd ever be able to take root again if I should break from my moorings."

So the other two went off to summon the Stentor and the Sun Animalcule, the Chilodon and the Coleps, the Amœba and the Arcella, to meet with them at the home of Bell Animal-

cule, to see what solution of the vexed question they could find.

When they met in council the philosophers did all the talking, as usual. It is impossible to reproduce here all their learned discourses, but the pith of their argument was this:

"No one of us is the whole of his father, grandfather, etc.; so we can not be any one of these individuals, but must be some other individual. We eat and assimilate food, and make new matter which is not and never has been a part of our ancestors. So the greater part of us must be ourselves. Consequently, we are justified in thinking of ourselves as 'me,' and not as 'my forebears.'"

"Oh, but you are not treating the question fairly," said the mathematicians. "What is there of us but ancestor when we are first made? And if we are all ancestor then, what can we ever be but ancestor with a full stomach, or ancestor with an empty stomach? There is no telling into what morasses speculation may not lead us. But figures can not lie. If we take figures we shall arrive at the truth. Now let us try this. I have in me $\frac{1}{2}$ my father, $\frac{1}{4}$ my grandfather, $\frac{1}{8}$ great-grandfather, $\frac{1}{16}$ great-great-grandfather, $\frac{1}{32}$ great-great-great-grandfather.

$$\frac{1}{2} + \frac{1}{4} + \frac{1}{8} + \frac{1}{16} + \frac{1}{32} = \frac{31}{32}.$$

Hence we have $\frac{1}{32}$ to represent either victuals or the 'me.'"

"No, that proves nothing," said the philosophers. "You have gone back only five generations—not even to the dawn of history. There have been many prehistoric generations. And since the fractions representing the quantities of the ancestors decrease as you go backward, you'll probably get a larger fraction as the exponent of the 'me.' Try it for ten generations."

So the mathematicians set to work again.

$$\frac{1}{2}+\frac{1}{4}+\frac{1}{8}+\frac{1}{16}+\frac{1}{32}+\frac{1}{64}+\frac{1}{128}+\frac{1}{256}+\frac{1}{512}+\frac{1}{1024}=\frac{1023}{1024}.$$

The chief calculator, a Paramœcium Caudatum, added the column, and found that when ten generations were taken into the count, there was but $\frac{1}{1024}$ of the self or of food in each individual. They tried again with fifteen—with twenty generations, and obtained as the result $\frac{1}{1048576}$ for the equivalent of the "me."

Smaller and smaller it became, dwindling into the infinitesimal. If they could go back to the Infinite, they might find the self they sought—not otherwise. But it was not a SELF as they had loved to think it, but a wee little, invisible *self*.

The pretty Vorticella, always so modest and self-deprecating, glanced timidly at the result, then silently coiled her stem, hid among the mosses, and was seen no more. The haughty Stentors trembled in every limb. The philosophers and wiseacres were astounded and, for once in their lives, speechless. To think of being less than the smallest atom! Nothing—absolutely nothing but the sum of one's ancestors! One and all slunk away in consternation and chagrin, to ruminate upon the matter in private.

Only the merry little Coleps said:

"I can't see what difference it makes *who* we are so we're here and have a good time. I would as lief be one of my ancestors as one of my descendants. What's the advantage of being posterity? If I'm my grandfather, all I have to say is that I'm rather fond of the old gentleman. So here goes, old boy, for a jolly roll." And off he went, twirling like a top gone crazy.

.

But there is nothing in this world quite so delightful as the way in which philosophy can change its base when vanquished and driven from an untenable position.

Hence it was not long before one after another of the wiseacres began to emerge from his seclusion in the mosses and to say:

"Why, to be sure! That is all right. Your figures deal with our material bodies alone. And we have always said—at least we have always *meant*—that the self was something other than the body; something higher and more potent; something which gathers matter about it to make a body for its use."

Gaining confidence from the sound of their own voices, they began to spell with larger letters and to declare:

"The SELF is all. The body is nothing. What matter if our bodies *are* derived from our ancestors? The ME is the important part."

And finally they said: "We *have* no bodies. The ME, the SELF, only extemporizes a body as it does pseudopodia. 'We are only *Self*, and have no manner of being, save in the sense of SELF.'"*

At this juncture an insignificant little Chilodon ventured to ask:

"But what if the SELF is only the sum of our fathers' and grandfathers' SELVES? What if the sense of self is inherent in matter?"

* Thanks, Mr. Howells.

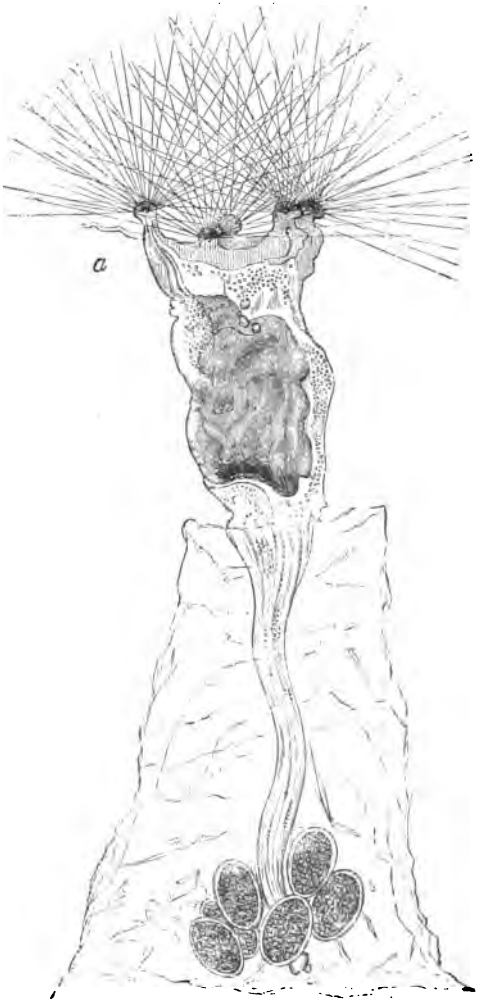


FIG. 25.—*Floscularia cornuta* (magnified).

At which the philosophers turned upon it such looks of contempt, and hurled at it such a shower of scornful missiles, that it was glad to scurry away beyond their reach, remarking to itself as it went:

"Well, anyhow, I have a sense of something or *other* which tells me that I'd better hustle my father and grandfather around to the other side of this island before the philosophers crack my skull."

CHAPTER V.

WHEEL BEARERS.

I.

(*Rotifera.*)

Down where the willows wave, and where they bend over and dip their branches into the pond, you will find the most beautiful species of the wheel animalcules. It will puzzle you, as it has the naturalists, whether to call them worms or crustaceans, for they have something resembling a crust or shell, yet you are sure to say, "This is a worm," when you see a *Rotifer vulgaris* walking by, making loops of his body as the "measure worm" does. (See Fig. 33.)

But when you see a Brachionus or a Pterodina drawing his head and feet inside his shell, you will say, "This is some sort of a mud turtle." (See Figs. 26 and 34.)

And when you see a Stephanosceros you will say: "Surely this is a stentor or a vaginicola,

for he has a lorica. But how does he happen to wear plumes?"

You can find the common rotifers in your *jardinière*, or almost anywhere; for the rotifer

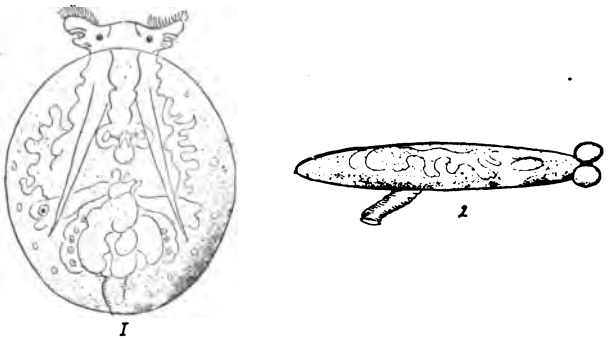


FIG. 26.—1, *Pterodina;* 2, a one-legged pedestrian.

may be dried till he falls to pieces at a touch, and still retain vitality in the dry powder. And this rotifer powder may be carried in the air by the winds, and may come to life in any vessel of standing water which contains enough putrefying vegetable matter to nourish the young animals. You can keep the powder on hand and produce a crop of rotifers at pleasure. In this way you may play at being Gabriel and awakening the dead. So, too, by gathering earth from the bed of a pond and moistening it you may resurrect many kinds of beings.

Or you can pour water containing microscopic animals through sand, and, after drying the sand, put it away in a dry place, such as a covered urn on top of the bookcase, and whenever you feel like having a resurrection morn you can pour water on the sand, and out of their graves will come trooping amœbæ, bell animalculæ, paramœcii, rotifers, and other sleepers.

(But this is another thing which you must not tell to your lady callers; for, if they would be shocked at the menagerie in the drawing-room, they would be even more horrified at a graveyard in the library.)

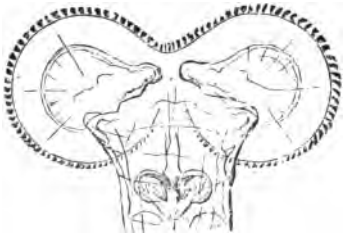


Fig. 27.—Wheel of tube wheel.



Fig. 28.—Two-lipped tube wheel.

Dr. Mantell says a rotifer can be dried and revived twelve times, and Professor Owen re-

lates that he saw one revive which had been kept in dust for four years. Fontana says in two hours he revived one which had lain dried and motionless two and a half years. Doyer says they endure exposure to a temperature ranging from 11° to 113° F. In dry sand they withstand a temperature of 150°; in moist, can not revive if heated to 131°.

Perhaps if rotifer seeds had been buried with Egyptian mummies, they would grow now, after three thousand years of entombment, like other seeds found with these rather over-ripe specimens of humanity.

The rotifer will endure cold as well as desiccation: A microscopist had a vase of water containing rotifers suspended from the bird-cage hook on his porch. One cold night the water froze, and the wind whipped the vase about until it broke loose and fell shattered to the ground. The next morning he found the ball of ice rolling around and put it in an empty fish tank, where it thawed. Putting a drop of this water under the microscope he observed twelve rotifers; which number had increased to forty twenty-four hours later.

Of one species they tell the amazing story that it can multiply to sixteen million in twelve days.

After that statement it is hardly necessary to say that young rotifers develop rapidly. In some species the egg grows, hatches, and becomes a full-grown animal in less than one day. The ambitious young animal is so eager to get started in life that his cilia and jaws may be seen to work before he leaves the shell, or before he leaves the parent in those that hatch before birth.

This is a new process of reproduction; for these animals do not multiply by dividing, but produce their young from eggs. This is also the first time we have noticed animals in which there is a distinction of sex.

Ehrenberg asserts that the *Philodina roseola* deposits eggs in a group and remains a long time with the young ones. If so, family life and parental affection begin among these lowly denizens of the ponds.

Romanes relates that he has seen a rotifer attach itself by its forceps to the side of a larger one, whereupon the larger one became very active, swinging about as if trying to dislodge its burden. Not succeeding, it laid hold of a weed with its own forceps and began a series of most extraordinary movements, throwing itself violently from side to side with such astonishing vigor and sudden-

ness as threatened to break its own toes or wrench off its foot. After a trial of strength which was prodigious in proportion to the size of the animals, and which lasted for several minutes, the smaller one was jerked loose. It returned to the conflict, but did not succeed in again establishing its hold. The entire scene, he says, was as like intelligent action as could well be imagined.

But although they are so much more highly organized than any of the preceding animals, they are only one fortieth of an inch in length, and are entirely invisible to the naked eye. Yet, when seen through a microscope, they look so large and rush about so rapaciously that you find yourself thinking of them as ferocious beasts.

Most of them are free swimming and very active. Some, as the tripod wheel bearer, are long and slender, like jointed grasses.

Some, as the pterodina and brachionus, are rounded and vase-shaped.

Some have two wheels, like the *R. vulgaris* and the brachionus; some have but one.

Some have a leg or foot made of tubes that slide into each other like the sections of a telescope. (See brachionus and *R. vulgaris.*)

Others, like the skeleton wheel bearer, have genuine articulated joints to this leg, which bend like the joints of your arm.

There are so many varieties that it is impossible to describe the half of them here.

The *Tripod wheel bearer* has a central tube into which slide anterior as well as posterior segments, so that the whole animal seems to be a series of telescopic tubes. It resembles some of the aquatic larvæ, having a small head-like segment, two black or very dark-red eyes, and one antenna. The mastax or mouth is situated in the main or central tube. The posterior segments can be elongated until the animal bears little resemblance to the other families of *Rotifera*, and is so attenuated as to look like a fine thread. The last segment terminates in three slender, divergent toes from which it derives its name of tripod. The wheels are small and seldom in action, and it is perhaps the only rotifer to which the term "indolent" can be applied.

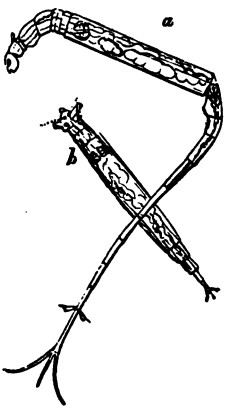


FIG. 29.—Tripod wheel bearer.

In the *Tube wheel* (Fig. 30) *e* is a nearly matured egg, which has a motion independent of

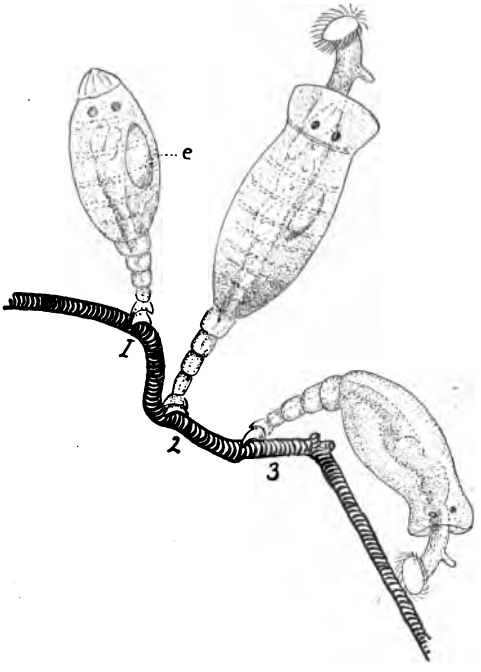


FIG. 30.—Tube wheels: 1, retracted; *e*, egg.

the parent's, and is about ready to begin a separate existence; doing this in a form resembling a stentor, having no wheel until it ceases roving and becomes sedentary. This rotifer has a single wheel, situated at the end of a bent tube, at the curve of which is a prong that is

probably an antenna. At the posterior extremity is a segmented foot terminated by two toes and a suction disk. The animal can bend freely.

The *Skeleton wheel bearer* has a three-sided carapace, the angles of which, in some species, terminate in single spines. At the last joint of

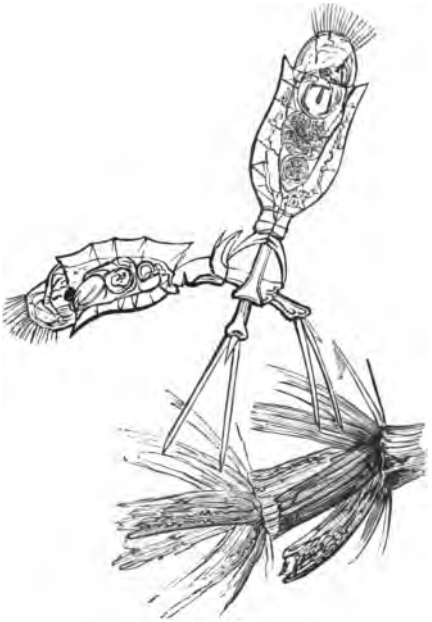


FIG. 31.—Skeleton wheel bearer.

the articulated foot are two toes which open and shut like the blades of a pair of scissors.

When anchored by these toes, it can bend backward like a lady making an old-time courtesy. It swims with the toes closed and held behind horizontally, but it bends them down at a sharp angle when it desires to turn about or alter its course.

The *Stephanoceros* is the beauty among rotifers. In place of the wheels it has five plume-like arms which are held open to catch unwary creatures wandering that way. The arms close together, forming a basket with a hole at the bottom leading to the funnel and œsophagus. When a little creature is entrapped the stephanoceros may be seen to swallow it with a gulp—that is, if your microscope is of sufficient power to reveal the rotifer himself; for he is hard to detect, being very delicate and transparent and living in a frail, colorless sheath.

We have mentioned the walk of the *Rotifer vulgaris*. It also swims by the action of its cilia. It has a proboscis which can be extended beyond the wheels, and on this proboscis are two red eyes. When it swims it projects a long horn or antenna. It has two toes and a suction disk by which it often fastens itself, swinging around in a circle, as the pterodina, the skeleton, and many of the rotifers do. In fact, so common and so useless is this performance

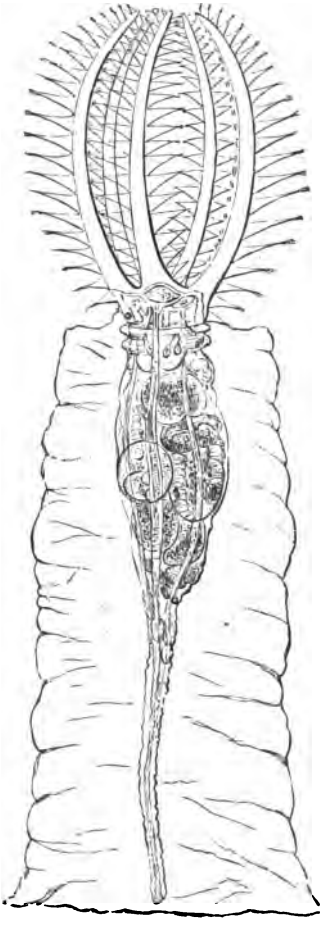


FIG. 32.—*Stephanoceros eichornii* (magnified).

among the rotifers, that it can only be regarded as a sort of national game of the wheel bearers.

The vulgaris is one of the viviparous rotifers, and through the transparent, moving vis-

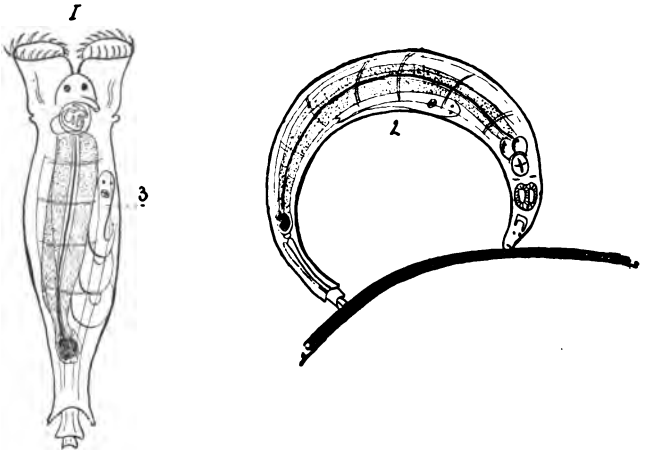


FIG. 33.—1, *Rotifer vulgaris;* 2, same walking; 3, young one.

cera of the body, a well-developed young animal may be seen.

Rotifer vulgaris is, as his name implies, the commonest of the wheel animalcules. You will see him everywhere, and will recognize him by his measure-worm pace, and by his habit of bobbing up serenely just when you don't want him, with an air of assurance which seems to say, "You sent for me, I believe."

So you and he will become thoroughly acquainted without further introduction, and we will spend our time with a rarer and more beautiful wheel bearer.

II.

(*Brachionus.*)

Brachionus pala, when viewed from the front, looks like an elegant fragile cup with bulging sides. From one side of the rim project four points, the middle two of which are slender and sharp as needles. The under side of the cup is flattened and ends at the rear in two blunt points, between which the grooved, proboscislike foot is protruded.

This rotifer has two large wheels, which seem to revolve rapidly, giving it the appearance of possessing great power. Between the wheels is a ciliated throat or funnel leading to the mouth, which, as in all rotifers, is situated *inside* the body back of the funnel.

This isn't the usual place for a mouth, but you see this is Nature's first experiment at mouth-making, and she hasn't yet learned the best location for one.

This is a genuine mouth, or masticating room, although so oddly placed. It consists of a pair of reddish-brown, club-shaped teeth and a flat plate or anvil. The food rests upon the anvil, and the teeth act as hammers to pound it fine. You may see the way in which they work by tak-



FIG. 34.—*Brachionus.*



FIG. 35.—Mouth of *Brachionus.*

ing scissors by the blades, and opening and shutting them so as to make the eyes of the scissors come together with the regularity of clockwork. In shape the eyes of the scissors resemble the teeth. You must not laugh at Na-

ture because her first teeth were hammers, for they were a great invention in their day.

The mouth is called a *mastax*. Back of it is a gullet leading to a stomach and an intestine which ends in a cloaca or canal for the expulsion of unassimilated food. Under the posterior portion of the body is a transversely grooved, flexible foot, which you are sure to mistake for a tail, because it whips about, reminding one of the tiger lashing his tail. But this appendage is a true foot, because it grows out from the ventral surface, while a tail terminates the dorsal surface, and because at the end of this foot are two toes which are used as forceps to grasp weeds and roots so as to anchor the rotifer.

The brachionus's use of this foot is often very comical. It will bend the foot forward, place it, push the body forward, lift the foot, and again set it forward, propelling the body with considerable force, and giving itself the grotesque appearance of a creature stalking about on one leg.

You see, Nature wasn't quite satisfied with the bristlelike legs of the Euplotes, and was trying to make legs of flesh. But she made the funny mistake of thinking *one* leg was enough, if it had two toes at the end of it.

The brachionus wheels up to an object, swings round, catches hold with its forceps, pushes itself out to the length of its foot, protrudes its disks, and begins to rotate its wheels, —except that the wheels do not actually revolve. The cilia merely fall over and pick themselves up in regular order so rapidly that all you see is a dark wave traveling around, which makes it seem that the disks are rotating.

The brachionus is the most ferocious of all the animals we have yet met. When it rushes forward, tail-like foot lashing its sides and jaws extended to seize its prey, it presents a truly formidable appearance, not to be expected in a creature so fragile and microscopic. There is a suggestion of the beasts of the jungle in the satisfaction with which it pounces upon its victims.

The shell or carapace is of palest amber color and so transparent that every organ of the body may be seen through it. At times large oval bodies may be observed inside the carapace or attached to the outside near the top of the foot. These are the eggs. They are soft when exuded, but afterward form a hard shell which is so thin that the movement of the young one is visible through it. As it nears the period for hatching, the red eye appears,

the ciliated disks begin to experiment to see if they are in good working order, and the jaws go through the motions of grinding food. The baby rotifer is trying its teeth before it has any food to eat. Finally, he becomes impatient of his prison walls, and writhes about till the shell cracks,—the top flying back as though on a hinge. Then the little rotifer glides out, selects a good site for a home, anchors, and begins to ply his wheels like an old and experienced person.

Young animals have the advantage of young human beings in this respect: they do not need to learn how to live. A rotifer can wheel, a chick can pick up food, a young robin can build its nest the first time it tries, without having to go through a tedious apprenticeship as a child does before it can even stand alone.

A Mistress Rotifer carries handsome, large eggs when she means to hatch girl rotifers, and small ones when she intends to hatch boys. And she considers girls so superior that she will not have boy eggs in the same filling of the incubator. The boy rotifers are smaller, have no carapace, no mouth, no spines, no jaws, no stomach, no wheels, and only one circle of long, strong cilia at the front. They move swiftly and have but a brief life.

III.

Many boys kill or abuse the lower animals because they do not appreciate how wonderful they are, and never think that birds and dogs and cats enjoy and suffer almost as much as people do.

A boy of this sort was one day raising a stone to throw at a frog which sat croaking on a log above the water.

"Don't hit him," said a bystander; "he's a relative of yours."

"He? A relative of mine?" asked the boy in amazement.

"Yes, you belong to the same great family of vocalists. He is the lowest and you are the highest member. Did you never think how silent the fish and clams and snails and all these water animals below the frog are? He is the first being with a voice. His croak is the first step in the evolution of the English language. The frog is the first thing that learned to talk. And he is related to you in other ways: All these animals below him breathe water and live in water; he begins life as a tadpole, voiceless, living in and breathing water; but by and by he climbs up out of it

and breathes air, living on land and talking in a language of his own as you do."

"Well!" said the astonished boy, "You're rather a toothless old chap, Grandfather Frog, and your voice is so cracked I can't understand

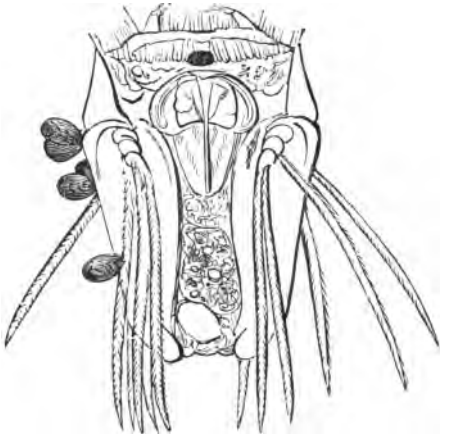


FIG. 36.—Sword bearer.

what you say, but I think, instead of stoning you, I'd better make your acquaintance." And he squatted on a stone with his chin between his knees in an attitude very like the frog's, and began to watch the croaker intently.

And, like the boy, you will feel new interest in the wheel animalcule, and will say, "I'm glad to make your acquaintance, Uncle Rotifer,"

when you learn that, way down in the scale of life, here in this fragile little creature, entirely invisible without a microscope, there is to be found a genuine brain and a true eye.

(How far back we mortals must go to find the beginnings of us!)

In front of and above the mastax of the brachionus is a large mass of diffuse nervous matter, a *brain;* and situated like a wart upon it is a crystalline lens, a square eye of crimson color and of high refracting power. That the rotifer uses this eye is shown by his bending his body in the direction of an approaching morsel of food and plying his wheels with renewed energy.

This also proves that he uses his brain; for the more energetic action of the wheels at prospect of reward shows intelligence. So, too, does the fact that he will depress the rim of the funnel on the side nearest the object he is trying to secure. He does this with the evident purpose of making it easier for the food to slip over the rim into the funnel.

But if we find such pronounced intelligence in the rotifer, we may know that intelligence had its beginnings far below the rotifer. When you come to study mineralogy and see with what care and exactness each molecule selects

just the niche for which it is adapted, or when you study chemistry and see with what intelligent preference the atoms of oxygen pass by those of nitrogen to eagerly unite with those of iron, you will say, "Father Molecule and Grandfather Atom, I am delighted to claim relationship with such brainy and interesting people as you." For you will know then that the roots of you reach down through frog and rotifer to plant and mineral, and that in very truth you were made, or *begun*, ages and ages ago, "out of the dust of the earth."

IV.

The waters are quiet, the sun is shining, and everything is smiling in placid beauty, as though there were neither death nor misfortune in this watery world.

A beautiful green creature, knobbed all over and shaped like a mulberry, comes through the water smoothly rolling on its axis, dreaming that life is a summer sea.

Its real name is *Syncrypta volvox*, but we will call it Jonah Volvox. It seems to be reveling in the exhilaration of motion, to be full of the *joie de vie*, which is what the French say

when life seems so exquisitely delightful that merely to be alive fills their cup of happiness to overflowing. It swims smoothly along, all unaware that in the little bay just around the point of the cape made by the mosses a powerful brachionus is plying his engines, spreading his ciliated net, and saying, like the spider to the fly:

"Will you walk into my parlor? Do walk in! You are my especial favorite of all the delicacies I meet."

Jonah Volvox sees and hears nothing of all this. All unsuspecting, he rolls along, rounds the point of the cape, and is caught in the whirlpool made by the rotating wheels. Round and round he goes, a helpless captive. No cry of his making, poor thing! can bring the outside world to his rescue. His despair is unheeded. He travels in narrower and narrower circles, and at last shoots straight down between the ciliated wheels into the ciliated gulf.

Now the sides of this tubular gulf contract to prevent his escape and to force him down onto the mastax. The jaws of the mastax gape wide and try to close upon him. But he is too large and too round. He slips away. Again the walls contract and the jaws gape wider,

but can not grasp him. Again and again, with increasing vigor, the jaws try to seize him, but each time he eludes them.

At length the rotifer in disgust spews him out of his mouth and casts him beyond the outer eddies of the whirlpool.

Now you wonder how it was with Jonah Volvox? and whether he had to be taken to the hospital, the morgue, or to the undertakers?

He was taken to none of these. He was not even hurt, though he *did* look rather discouraged as he rested among the weeds at a safe distance, pondering on the ups and downs of life.

He seemed to be wondering just what had happened to him, and how it all came about, and what could be the meaning of it.

After a time he took courage again and said: "What's the difference? We must take things as they come, and life is pretty jolly, after all. So here we go again!" And away he went, smoothly gliding and revolving, as though nothing had happened.

But now it chanced that Jonah's little son had been swimming along after him, trying, as boys will, to do everything their elders do; and while his father was resting among the

reeds on the opposite side, meditating on the ways of life and forgetting all about the little fellow, the child swam round the point of the cape where he had last caught a glimpse of his father, and he too disappeared in Charybdis and was never heard of more. No ear caught his faint shriek of terror as he shot down the ciliated funnel; and as it contracted, the jaws opened, and, finding him small enough, took him in, closing tight behind him.

Then he was laid upon the anvil and the two hammers began to beat upon him, pounding him into very tender beefsteak, such as tickles the palate of the brachionus. When he was sufficiently pommeled, he was forced down the gullet into the stomach, and, when the rich juices were extracted from him, all that was left of his battered form was expelled from the cloaca.

But even his parents and nearest relatives would never have recognized those dry bones as the mangled remains of poor little Jonah Volvox, Jr.

CHAPTER VI.

CRUSTACEANS.

It may be that Nature herself saw the grotesqueness of having a creature stumping about on one leg. At any rate, she seems to have thought best to try making animals with several legs. She also wanted to invent some sort of lungs. So she did one of the funniest things yet: She made some little animals called *Crustaceans* (because they have a crust or shell), and gave them a great many legs which they can draw up inside the shell when it is bivalve; and she put the lungs *into the front feet* of some.

This is why they are called "Branchiopods," or breath-footed.

Some of the crustaceans, as the daphnia and cypris, have a thin bivalve shell—that is, a shell of two parts or valves which open as though there were a hinge between them; others, as the branchipus, canthocamptus, etc., have a shell

of chitin arranged in rings or somites like the abdominal segments of the lobster, the insect, and the spider. These bodies of chitin are usually composed of twenty-one somites, and would be unwieldy except that the segments can slide into each other as telescopic sections do, only these overlap more readily on the under side so that the animal can bend downward but not upward. Most joints have a habit of bending in one direction, like those of your elbow and knee. It is only now and then that some "limber Jack" is found who can make his arm curve forward and his leg curve backward; and it is only occasionally that one of the crustaceans, as the canthocamptus, can throw his heels over his back and hit his head.

The children of many crustaceans are built on an entirely different pattern from the parents, having a nauplius form (see Cyclops, Fig. 39, *a*) with a body less elongated and lacking in some of the limbs with which the adult is provided. In some cases, however, Nature favored the young at the start with the whole twenty-one somites, afterward causing some of the segments to coalesce so as to form one out of two. Occasionally, among the *Phyllopoda* and *Branchiopoda* one finds as many as sixty somites, and each somite is supposed to have

a pair of legs or other appendages belonging to it.

Now it would seem—of course we would not think of criticising Nature—but it *would seem* that to jump from a creature with but one leg, like the rotifer, to a creature with one hundred and twenty legs, was a feat to be expected from a professional athlete rather than from a staid old dame, like Nature. And it appears that Nature herself thought she was carrying matters rather too far, for she turned some of the anterior appendages into mouth and sense organs, caused the posterior appendages to dwindle in size, and finally she eliminated some of them entirely, so that the poor animal would not have to spend quite all its time in thinking which of the one hundred and twenty legs to set ahead next.

But the anterior appendages do not seem to be entirely pleased with the new duties to which they are assigned. They change about, acting restless, as though they had not made up their minds whether to settle down to a permanent occupation, or, indeed, whether to locate at all; for the legs which were turned into antennæ are, in some species, organs of touch; in others, organs of locomotion; in others, they are *nurseries* for the young. The

eyes of some species are sessile; those of others grow on stalks as though they were still determined to be legs; and those of others refuse to exist at all. Some of the appendages which were made subservient to the mouth, the maxillipeds or feet jaws, try to revert into feet; for while in some of the crustaceans the mouth organs extend to the ninth somite, in others they extend only to the seventh, the eighth and ninth refusing to perform the functions of nutrition, and preferring to assist their owner in getting about in the world.

The young crustacea have as many odd cradles as they have odd shapes to their bodies. The young canthocamptus rocks on the waves in a sack attached to the body of the parent; the mysis lives in a pouch like a young kangaroo; the crabs are glued, in a mass similar to a spider's ball, to the legs of the mother; the arcturus is cradled in the branching horns or antennæ of the old one; the daphnia is carried under the coat on the back of the mother; while the prodocerus lives in a genuine little bird's nest down deep in the sea.

I.

(*Daphnia.*)

In the fall, when most of the aquatic vegetation is dead and the water of the ponds is clear, a great many small round specks may be seen jumping and jerking about.

One of these animals is the *Daphnia* which has an oval bivalve shell and, usually, a spine

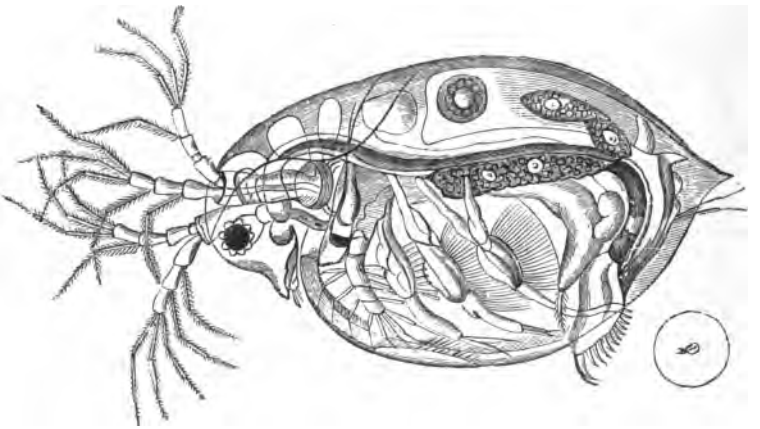


FIG. 37.—*Daphnia pulex.*

above the middle of the posterior portion, though this, like the teeth of higher animals, is generally absent in old specimens. Through the lower opening, between the two valves of

the shell, you will often catch a glimpse of something protruded and withdrawn with such lightning rapidity that you are not sure it is not an optical illusion until some time when the daphnia is lazy or is nearly exhausted for lack of water and fails to withdraw this object, and then you perceive that it is a foot or claw, tipped with bristles, and that it is the action of this claw which gives the animal its irregular, jerky motion; for, instead of sailing or crawling or swimming along, the daphnia *kicks* itself along by pushing this foot out behind. When necessary it uses this brushlike claw for scavenger and police duty. It welcomes all comers, protozoan, egg, vegetable matter, and even particles of poison coloring matter, packing them in till the vestibule in front of its mouth is full; then it opens the door and samples them. If it does not like their flavor, it kicks the whole mass out and sweeps the vestibule clean with its broom. In front of this claw are many smaller, fringelike feet, which are seldom protruded from the shell, but which move regularly with a breathing motion. Above these feet, about midway along the animal, is an alimentary canal ending in a cloaca. The canal, feet, and claw seem to be entirely free from the shell, and are all, at frequent intervals, bent

down and forward, leaving the back and rear of the shell empty. This habit distinguishes the daphnia from others of these small crustaceans, none of which move the claw except downward and backward. Above the canal, close under the top of the shell and near the head, is a rapidly pulsating heart, which sends colorless blood through the body two or three hundred times a minute.

The head of the daphnia is a large, rounded beak, at the extremity of which is an enormous eye, of a color so dark green as to appear black. It is turned by three pairs of muscles, and is the first movable eye we have seen. From either side the neck grows something you would call stag's horns. These are the large, branched antennæ, round and jointed like a bamboo pole.

Along the back, under the shell and above the body, is the brood cavity in which there are sometimes eight or ten eggs. This is the incubator, in which the eggs are hatched and where the young are cared for until they are fitted for an independent life.

If the children are too ambitious to see the world in their youth, the mother promptly kicks them back into this nursery; for the young are sprawling, helpless things, having no shell, no alimentary canal, and only three

pairs of feet, and the mother thinks no one is fitted to appear in polite society until she has at least ten feet.

This is one of the creatures that have summer and winter eggs. All summer there are none but lady Daphniæ, and they lay the summer eggs and rear the "summer girls." When haying and harvest are over, about the time that you begin to watch for the falling leaves and dropping nuts of autumn, the lazy gentlemen Daphniæ come pushing their way through the water with an air of great importance. They prefer the winter time, when there is not much to do except skate about under the ice.

When spring work begins again, only one kind of Daphniæ are to be found, the gentlemen having taken their departure.

II.

(*Cypris.*)

There is a little kidney-shaped *Cypris*, which, when green and lying quiet with feet drawn into the shell and its house securely locked, may easily be taken for a leaf of duck-

weed. The deception is still more perfect when the shell is ornamented with mosses and filigree in the shape of diatoms whose shells are attached to the cypris, making a fringe around it.

When the cypris travels it opens the two valves of its shell just far enough to permit the protrusion of the two pairs of antennæ and the four long, hair-tufted clusters of bristles which it palms off upon us as feet. It swims rapidly by jerking these feet back and forth. When molested it quickly withdraws them and sinks to the bottom. When trying to walk on these pencils of bristles it wobbles ludicrously.

One pair of antennæ is long, jointed, and feathery, and is used for swimming; the other is stout and footlike.

The cypris deposits twenty-four eggs in a mass, afterward taking each egg singly and spending about thirty minutes in gluing it to vegetation. When the little one hatches as a nauplius with three pairs of appendages, it has a house already on its back, and in four and a half days it can not be distinguished from its parents.

When the water of the pond dries, the cypris, following the example of other crustaceans, hides in the mud. It evinces great wisdom in so doing, for if all the moisture

evaporates and the mud becomes dust the little creature is sure to die; and then, you see, if it had not taken the precaution to bury itself before dying, it would have to go unsepulchered because all its friends would be dead too, and there would be no one left to dig its grave. But if the rains come before the mud is baked, all the cypris has to do is to creep out of its hiding place, rub its one eye, and pretend it has only been taking a nap.

The eggs survive in the dust and heat, so when the rainy season comes the pond is soon full of lively cyprides, which are green, brown, and dull white, but none of them very interesting,—perhaps because they are so omnipresent.

III.

THE FAIRY SHRIMP.

(*Branchipus.*)

There are some crustaceans that are truly charming in dress and manner, and such a one is the *Branchipus*, or Fairy Shrimp. (See frontispiece.)

Very early in the spring they are to be found in the shallow pools formed by melting

snow. From such a pool, and in no very mysterious manner, a company of these fairies used every season to find their way into a house in a certain little city of the western prairies. They always came in a bright tin pan, within which the beautiful pearl and pink creatures swam on their backs, gently rowing along with their eleven pairs of swimming feet uppermost. They were a pretty sight; and the thought of them is still associated with that of early flowers and the budding freshness of springtime. But the pan had to be kept in a cool place, or presently the fairies vanished; for they can not endure heat, and by the middle of May they are a story that is told. The pool is full of them one day, and, if the sun comes out warm, the next day they are fled, leaving no trace behind—except for the zoölogist, who can recognize their eggs.

They are the largest animals we have yet noticed, being sometimes an inch in length, with stout bodies, large heads, and very large eyes. In front the male has two unequal appendages, and on one is a bristlelike claw. (See frontispiece.) The female carries a single egg sack, which is a modification of the eleventh pair of feet.

In this fairy Nature seems to be making

another of her experiments. With the exception of the daphnia's, eyes thus far have been dim, and would not turn so as to look in various directions. So Nature has set the eyes of the fairy shrimp on *stalks*, that they may look about the world more readily. You see, she made several experiments with eyes before she achieved man's eye. In the first place, there was the dim sense organ of the euglena, placed flat in the front part of the body, with no socket, and entirely unable to turn or to see. It could barely distinguish light from darkness. Then there were better eyes, like those of the rotifer, but still they could not turn and could see only what lay in one direction. Then came the stalked eyes of the branchipus and its kindred, the lobsters and crayfish. But these eyes are likely to be broken off, standing out from the body as they do. So Nature tried making sessile eyes—that is, eyes lying mostly in sockets so as to be protected by the body; and she gave to some a transparent lid, and to some a movable lid to close over and further protect them. The first of these eyes were placed on opposite sides of the head, like those of a fish or a robin. But these were still not satisfactory, for the two eyes do not see the same things, one looking to the right, the other to the left,

—you know how a robin has to turn its head to see what lies in front of it? At last, Nature made the large, movable, lid-shielded eyes of man, which can look forward and can focus on the same object; and she set them in a head supported by a slender neck, so that the head may turn and allow the eyes to sweep the whole circle of the horizon.

And now, perhaps, she need make no more experiments; for she has joined with these eyes a brain which can work out her experiments for her. When there is need of an eye which can see more minutely, the brain invents a microscope or a pair of spectacles; and when there is need of an eye that can see millions of millions of miles into space, the brain invents a telescope.

IV.

(*Canthocamptus.*)

You have been waiting for the clown to make his appearance, and here he comes tumbling into the ring, one moment traveling on his side and the next bundling along with head and heels touching each other. He is a great contortionist, having a body made up of jointed segments so that he can bend it readily.

If you don't use your opera glass you will think he is a tiny worm wriggling along, but if you do use it he will appear for all the world like the gentleman in Fig. 38. He has one eye, two pairs of antennæ, and five pairs of legs, but, as in most of these minute crustaceans, the antennæ are of more service than the

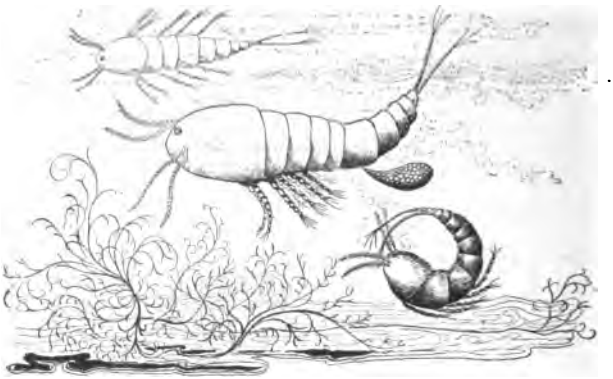


FIG. 38.—*Canthocamptus.*

legs in swimming, though under the microscope he seems to propel himself by vigorous flexions of his tail.

His body is largest in front, and is long, narrow, and shaped like an Indian club, except that the under side is flattened. He usually clothes himself in a single garment of dull, dirty hue, but sometimes wears pink or flesh-color.

Our clown seems to be of rather an irritable disposition. Two of them once became penned in by threadlike roots which happened to be in the ring. They rushed this way and that, trying to escape, flexing their heels over their heads angrily, seeming much distressed at their situation. At length one, evidently blaming the other for his capture, seized his companion and hung on like a dog, apparently by his teeth. It was a savage grip, and relaxed only when the water on the slide dried, and death came to the relief of both.

Like misers, they carry a bag of gold; but this kind of gold is made into transparent balls or eggs, and is borne in a sack attached to their bodies and floating beside them. These eggs hatch in the sack, for this clown of a canthocamptus and his kindred, the branchipus and cyclops, do not wear a shell nor have a brood cavity as the daphnia does. They dress in tights made of a thin crust like that worn by the lobster and crayfish.

You would never know that the children belonged to the family if you should meet them, for they do not resemble their parents in form or feature. In about two days they molt, or peel off their tights, and this cast-off garment carries with it the cases of the limbs and plumes

even to the most delicate hairs. But the young one that comes out has all these again, and often new limbs, and each succeeding time a shape more like its parents', until after several moltings it comes out a full-grown perfect canthocamptus.

A curious thing about this is, that if a limb be broken or torn from one of these young animals, it recovers that limb when it molts the next time.

One might almost think the crustaceans knew this, from the readiness some of them evince in parting with portions of their anatomy; for, if you lightly touch the joints of their legs with a pin, they instantly discard the lower joints.

And this is something which we may apply to human beings; for perhaps, if we have lost arms or legs or even mental faculties, or even if we never possessed those mental faculties, but have been deficient in them as the young canthocamptus is in limbs, we may recover all we have lost and obtain yet more when we molt,—or as we usually express it, when we die and go to heaven.

There are some people who wish they could overcome death and preserve their present bodies forever. But you see this would be a

disadvantage, for they could never recover the amputated limbs nor the lost minds if they didn't slough off this outgrown sheath of a body; neither could they acquire faculties in which they have always been wanting.

So, too, it seems that it would be a disadvantage for us to molt but once, and then to remain forever and forever in the next stage, as people used to think we would; for that would mean that we ceased to advance after this one molting which we call death.

And don't you think it would be better to keep right on growing and molting, acquiring new faculties each time like the young crustaceans, and each time coming out of the old case more and more nearly resembling our one perfect Parent and Creator?

"But what has this to do with canthocampti or cyclops or diaptomi?" Why, this: they have taught us what a blessing death is.

V.

(*Diaptomus.*)

The most brilliant creature of all is the scarlet *Diaptomus*, with its six thoracic segments, its five narrow abdominal segments, its brush-

like tail of two parts, its jointed, feathery feet, and its two antennæ as long as the body. The antennæ are jointed and curve gracefully backward when the animal swims. The heart may be seen to beat under the middle of the carapax. The legs are made of flattened segments, and so feathered as to resemble palm plants.

The female carries one external ovary or egg sack. The diaptomus is one tenth of an inch in length, and, like the branchipus, is a lover of cool water, being found only in fall or early spring, and making its home in shallow pools. The one most common with us is red; but there are those that wear white, others with robes of purple, and others that wear blue and have antennæ tipped with bright purple.

It might be mistaken for a cyclops, from which it may be distinguished by its unusually long, single pair of antennæ, the cyclops having two pairs of shorter ones. It has a comely figure, but its chief beauty lies in the brilliant color which extends through antennæ, legs, and body, even to the tip of its tail.

VI.

THE ONE-EYED GIANT OF THE MILL POND.

(*Cyclops.*)

There is an old poem that the Greeks used to love which tells of the trials and dangers that beset the hero Ulysses—or Odysseus, as they called him—as he journeyed homeward

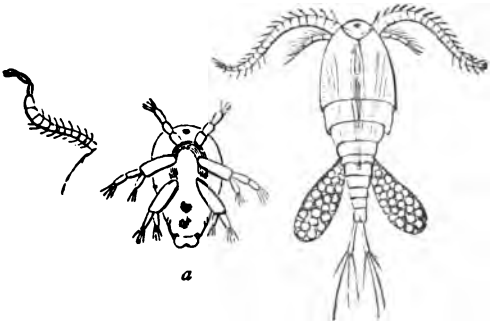


FIG. 39.—*Cyclops quadricornis: a*, young.

from the Trojan war. It took Ulysses twenty years to reach his home, and he had so many narrow escapes the wonder is that he ever reached it at all.

On one occasion in particular he came very near to death. As the story goes, his ships were swept by storms against a strange coast. Ulysses and his companions went ashore to ex-

plore the land, discovered a cave, which they entered, and, finding presses full of cheeses, vats full of milk, and casks of wine, they feasted and made merry, not knowing that the cave was the abode of a fierce and terrible Cyclops, a huge giant who had one fiery eye set in the middle of his forehead. At sundown the giant came home, drove his flocks into the cave and shut the door. The door of the cave was a rock, so immense that Ulysses knew he and his men would be powerless to remove it. He saw that they were prisoners, and the giant looked so terrible and roared so frightfully that the captives shrank trembling into the farthest recesses of the cavern. When the Cyclops had milked his flocks he built a great fire, and approaching Ulysses and his men he reached forth his hands, seized two of the men by the heels, swung them around, cracked their heads together, and soon had them broiling over the fire. Their terrified friends stood by helpless as the giant crunched their bones with his huge teeth. The next morning he killed and ate two more in the same horrible manner. When he drove his flocks to pasture he took good care to put the rock over the opening of the cave so that his captives should not escape.

That night he killed two more, and washed them down his throat with such quantities of wine that he fell into a drunken sleep. While he slept, Ulysses and his men bored out his eye with a sharpened timber which they had heated red hot in the fire that broiled the last two of their unfortunate companions.

But, though he could no longer see, the Cyclops was wily, and he sat by the door of the cave, stretching his arms across and feeling the backs of the sheep as he let them out in the morning so that the prisoners might not escape by riding out on the sheep's backs.

So Ulysses and the remaining men were obliged to cling fast to the wool on the under side of the sheep and be carried out in that way.

.

And simply because it has one red eye in the middle of its forehead, the name of Cyclops has been given to a wee little "oar-footed" crustacean, not more than one sixteenth of an inch in length, and not at all resembling a fierce and terrible giant. It seems a very happy, lively little cyclops, constantly skipping about, and keeping its feet incessantly paddling the water.

The cyclops has no heart, the blood being

kept in circulation by the churning motion of the intestine. It has four pairs of branched legs, and mandibles and maxillæ fitted for biting. It feeds upon infusoria and smaller crustaceans, at times maintaining a catlike quiet till the animals collect about it and then suddenly pouncing upon one.

But, unlike the giant, it lives not so much to eat as to be eaten, for it furnishes the principal supply of food for the smaller fishes and the aquatic larvæ. Even the larger inhabitants of the sea feed upon it, so that when fishermen and whalers see schools of cyclops they get their nets and harpoons ready, knowing that their prey is at hand. Hundreds of square miles of ocean are sometimes filled with these little one-eyed creatures, for they are immensely reproductive. Each female carries two egg sacks, which contain from forty to fifty eggs, and she brings forth from eight to ten broods. The young soon become parents, so that a cyclops may become the progenitor of 4,500,000,000 in one year. On the 28th of February, 1896, while the ponds were still covered with ice and there was only a narrow border of water extending a foot or two from the shore, a close observer might have seen great numbers of cyclops darting about close to the

beach, and, cold as it was, they carried weight like John Gilpin, "a bottle dangling at each side"; for the egg sacks were heavily laden and the young had already begun to hatch. The bottles are pear-shaped, sometimes dark green, sometimes amber-colored. The young hatch in the sacks, and may be seen moving inside the eggshells. But "like parent, like child," is an adage that doesn't seem true at first in the case of the nauplius of the cyclops, for the young are quite unlike the parent, having to molt several times before they attain the same shape and appendages.

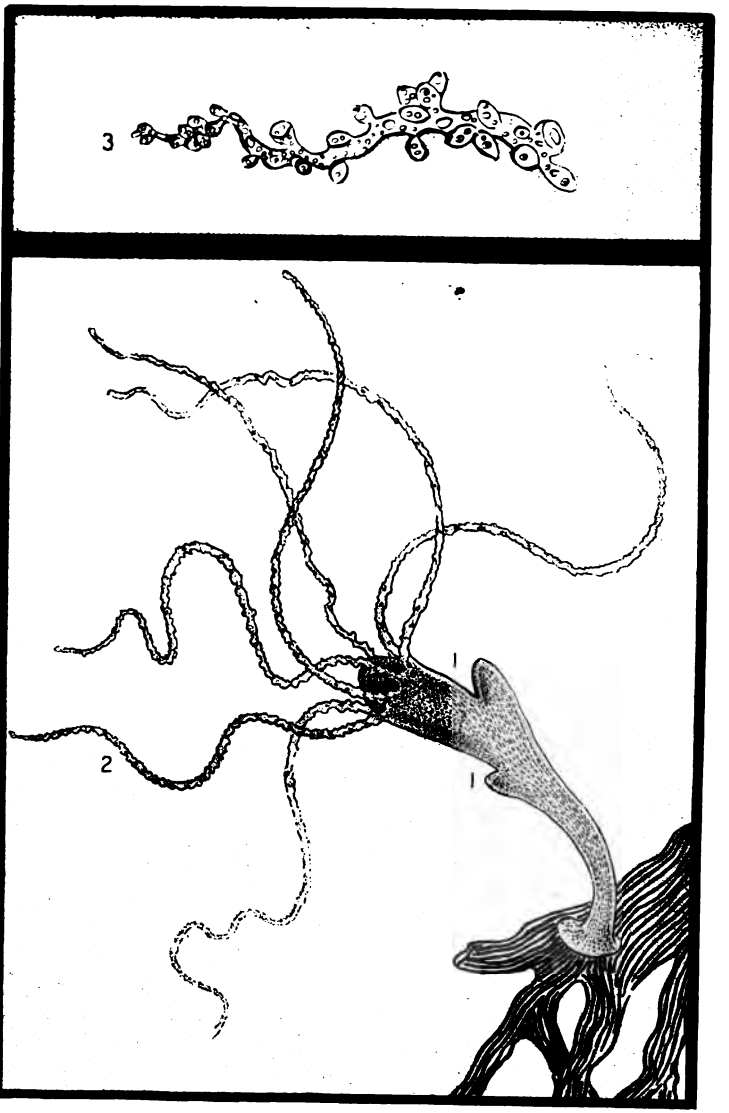
The eye of the adult cyclops is really a cluster of eyes, so placed as to appear to be a single one.

The eye of the nauplius looks like two triangles joined at their apexes, and resembles no other eye that ever was on land or sea.

In the matter of diet the cyclops is like the giant of the Greek fable, for it is a regular cannibal, devouring beings like itself, and even eating its own young; which is perhaps a good thing, since there are thirty species of them, and even though they do eat their kind, there are plenty left, and they may be found all the world round and all the year round. They abound in all stagnant pools, in the water

which the Londoner drinks, in that from Croton River which quenches the thirst of the resident of New York, and there is a little fellow skipping about in the pitcher of Springfield (Illinois) well water that stands on my table as I write. This one is a pale little fellow, coming from so far below the sunlight; but it has egg sacks, as I can tell without a microscope, because it ends abruptly at the rear, as if cut square off, instead of tapering toward the tail.

CHART IV



Hydra.

CHAPTER VII.

THE HUNGRY GLOVE.

(*Hydræ.*)

As late as November 10, 1889, I dipped some water and duckweed from my favorite pond and put it in a glass jar. An old man in charge of the city waterworks near by, who had many times watched this canning of slough water with an expression of wondering disapprobation, at length took courage to come forward and investigate the matter. "I've been puzzling myself over what you do with that," he said.

"I put it under the microscope and study the animals in it."

"Animals? Taddypoles and sich?" he asked, incredulously.

"No, much smaller ones. Look through this jar toward the light. Those specks darting and jerking about are cypris, daphnia, and cyclops."

"Be them dirt specks animals? Now, do tell!"

"Dirt specks always fall to the bottom. They can't dart up toward the top and sidewise. And in here there are probably tiny hollow tubes, called *Hydræ*, with fingers or tentacles at the end which look like a very small kid glove rolled together so that the thumb and little finger touch. Although they don't look much like one, they always remind me of a glove, because they can be turned wrong side out, fingers and all, and then turned back again without injury, just as a glove can. And there are hosts of other animals, shaped like bells and cups and boats, which are entirely invisible."

"Live animals that can be turned wrong side out and others that you can't see at all! Now just see that!" remarked the old fellow in growing amazement. "And *them's* what you git it for! I *wondered* if you could be *usin'* of it," he said, with evident relief. And he went back to his work, muttering to himself: "That there puddle swarmin' with live animals that can be turned wrong side out and that can't be seen! Now just think of that!"

Clinging to the light side of this can the next morning were what looked like a dozen

short threads frayed at the free ends. (See cut at end of chapter.) But to call them threads is to speak as through a microscope, for the speech magnifies them as much as a half-inch objective would. Instead, they were in size like the finest strand of a fine thread, with the slenderest possible lints or filaments fringing the ends. It would seem that nothing could be more attenuated. Certainly the tentacles of a small *Hydra viridis*, or green hydra, must be the ultimate object which the unaided eye can perceive.

The brown ones (*Hydra vulgaris*) were somewhat larger. A coiled one clinging to the glass looked at first glance like a small leaflet of Lemna with the roots attached. Another adult had a young one budded from its side, and the little one was extending its tentacles, trying to earn its own living in the world. Afterward I saw this baby clinging alone on the glass, a mere speck, with six almost imperceptible fibers radiating from its head, looking more like a minute poppy seed trying to be a star than like a living creature watching for its bread and butter. In another place a parent and child were trying to swallow the same worm.

The five or seven tentacles of the hydra are their arms, and surround the mouth, which

is nothing more than an opening at the top of the hollow tube. The tentacles are hollow and covered with warts or knobs (3, Chart IV), and in each knob is coiled a lasso with



FIG. 40.—Hydræ.

a sting at the end of it. The hydra sits with these long arms extended, and when its prey appears, throws out the lassos and paralyzes the victim with its stings. Then the arms bend over and force the benumbed victim down the hydra's throat.

The addition of a drop of acetic acid to the water on the slide will irritate the hydra, causing it to throw out its lasso lines. A shelled animal, like a crustacean, may be protected from the sting by its hard covering; but a soft animal, like a worm, always dies even when the tentacles do not convey it to the mouth.

The tentacles also assist in locomotion; for the hydra can bend over, as in 2, Fig. 40, holding on by the tentacles while it loosens its foot and sets it forward, like a measure worm.

These hydræ may be turned, tentacles and all, making skin into stomach and placing the stomach outside where the skin belongs. After two or three days they will eat again as voraciously as ever. You may tear off their fingers, and they will grow again. You may cut them into cross-sections, and each section will become a perfect hydra. You may cut them into strips lengthwise, and each strip will roll together into a tube, develop tentacles, and presently go on as if nothing had happened. You may even cut off the head of one and the mouth will go right along taking in food, like the man whose head was cut off by such a neat stroke that he never knew it was off, but kept on talking, till at length he sneezed, and the head fell from his shoulders and rolled along the

ground. You will know now why an evil which is irrepressible is said to be "hydra-headed."

The hydræ produce offspring by bulging out the wall of the body and forming a bud, which is hollow and opens into the body cavity of the adult, so that what the parent eats may enter the body of the offspring, and what the offspring eats may enter into and nourish the parent (1, 1, Chart IV; 3, Fig. 40). Sometimes the bud remains attached to the parent and itself buds before pinching itself off and beginning to live independently. A colony of nineteen parents, children, and grandchildren have been seen on one original hydra.

This is rather mixing up matters. But these fresh-water hydræ have some cousins who live in salt sea water, and who remain always attached to each other, with free communication between their body cavities, forming large colonies which spread out like a house of many compartments, with halls and corridors leading from one to the other.

In these marine colonies it is the business of certain of the hydroids to rear all the children, of certain others to act as policemen and protect the colony, and of certain others to secure and eat all the food for the colony.

In these colonies one would think that Na-

ture was making her first clumsy experiment at differentiation of matter to perform special functions, and had not yet learned how to condense her experiments into one body, for in these colonies we find different functions assigned to different individuals, and not to different parts of one individual. We human beings are quite willing that some one shall be appointed to take care of us and do our work for us, but I do not think, do you, that any of us wish to carry the principle of division of labor so far as to have another do our *eating* for us?

.

Our little Hydræ in the glass can (see cut at end of chapter) are doing their own work very energetically this morning. They are grouped all along the water ways on the brightest side of the jar, and are spreading their nets and fishing most industriously.

And now down the main street of this thriving aquatic city, right into the open arms of the Hydræ, there comes hurrying an important personage. His name is Sir Daphnia Pulex. He must certainly be a great railroad magnate, judging from his businesslike manner and the ease with which he brushes small fry away with one kick of that powerful hind foot of his. He comes pushing along with an air

which indicates that the machinery of the world is waiting till he arrives to set it in motion.

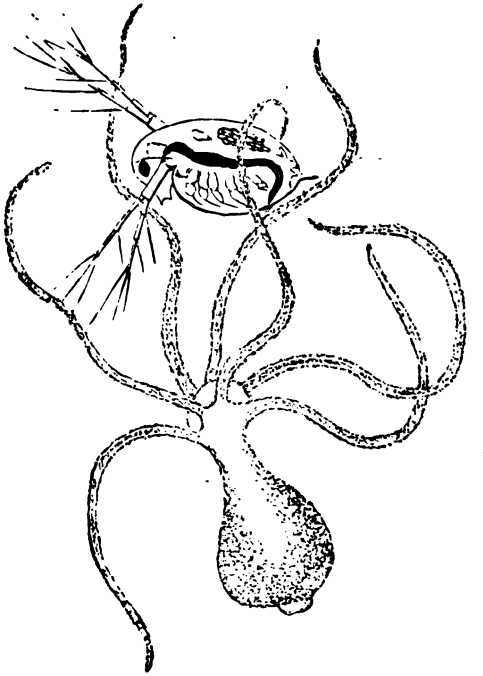
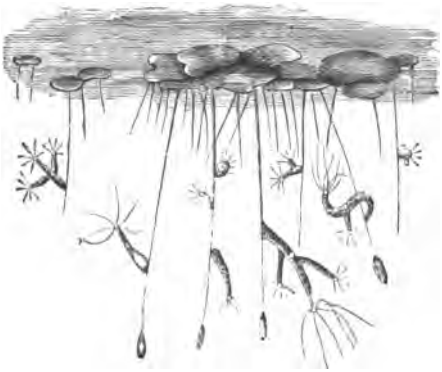


Fig. 41.—Hydra attacking a water flea.

But suddenly he pauses. Has he forgotten something? He does not turn back after it. He seems to have changed his mind, and to have concluded that the affairs of the world are of no great importance, after all. Ah! this

is what has happened: He has been hit by the loose end of a cable belonging to the Hydra-Electric Company, and the current has been discharged into him. His arms droop. His feet no longer move. He seems to be meditating. Perhaps he has been suddenly confronted with the problem, "Is life worth living?" and has decided in the negative. With one last sigh, "Adieu, vain world!" he disappears down the hydra's throat. To-morrow the newsboys of this moist city will be calling, "Tr'bune, Times! Thrillin' account of death b'lectricity! All about the tragic fate of Sir Daphnia Pulex!"

But, for the great magnate to-day, his errand is no longer pressing. He has hung his harp on the willows, and dies a captive beside the waters of Hydralon.



Hydralon.

CHAPTER VIII.

"PLANTS AT THE MOMENT OF BECOMING ANIMALS."

THE GREEN SNOWFLAKES.

(*Desmids.*)

EARLY in the month of March the water is filled with moving green objects which thrive in the cool season. They are the *Desmids*, and are plants in reality as well as in color, propagating by spores. They may be smooth or rough, warty or spined, notched or toothed, cut or divided, round or star-shaped, crescent-shaped or in bands of ribbons; but they are always evenly green in color, slow and stately in motion, and move only forward, not being able to retrace their steps without turning around. If a desmid moves rapidly or retreats without turning about, you may know that it is not a desmid but a diatom. It is frequently difficult to distinguish between the two, for the diatom is sometimes green, and both are found with

the individuals growing side by side in long bands; but the desmid adheres to stems of plants, never having a stalk of its own; it loves the place in the bayou where the sunlight falls, and it comes up to float near the surface; while the diatom forms the brown, yellow, and fawn-

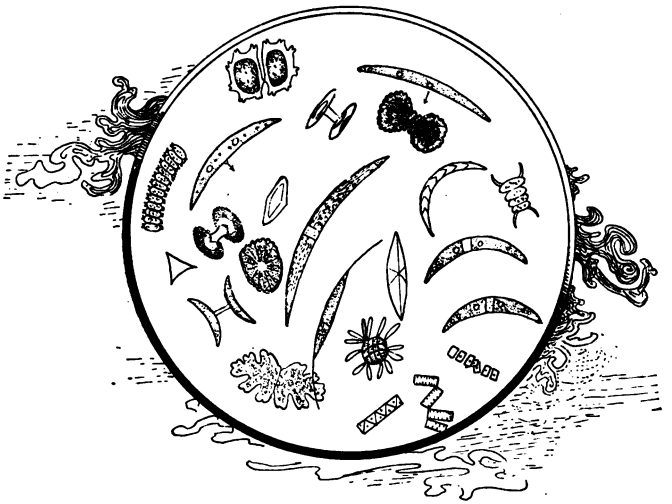


FIG. 42.—*Desmids;* ↑, *Closterium.*

colored coating on the rocks at the bottom of the shady nooks.

At the ends of the desmid, but not of the diatom, there are often empty spaces, near which a movement of liquid may be detected, which movement resembles the rising of bubbles or

the convection in water when heating. Besides the clear space at the ends, some of the crescent- or bow-shaped desmids belonging to the *Closterium* family have a clear space in the middle, and have the pulsatile vesicles arranged in two pairs (Fig. 42).

Some of them are very pretty, and are named *Eurastrum*, or star disk, *Micrasterias*, or little star, etc.

The desmids are most active and most numerous in March and April, which is their time for conjugation. They multiply by fission as well as by spores, and when dividing, one part remains quiet while the other sways about and breaks off with a jerk. Then the ends that were attached round up and assume the customary shape of the species.

There are more than four hundred species, all living in clean, placid water, and so afraid of the restless salt sea that they will not grow in running streams, for fear of being carried down to the ocean.

II.

THE FIRST MUSICIAN.

(*Diatom.*)

The people of Sweden and Norway use for food an extremely fine, cream-colored powder

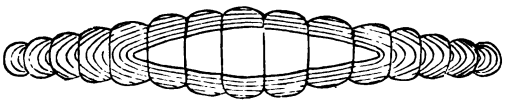


FIG. 43.—*Orthosira Dresseri.*

which they find in the mountains and which they call "mountain meal."

In Italy there is a white earth that is used in the manufacture of candies.

The meal and the earth both consist in deposits of immense numbers of very minute

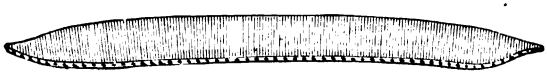


FIG. 44.—*Nitzschia vivax.*

animals, called *Diatoms*, which have thin silicious shells. Thirty miles above San Francisco is a white clay composed of the same thing. The flint which is used for Indian arrowheads

is fossil shells of diatoms hardened by the internal fires of the earth.

Grindstones and whetstones on which you sharpen your hatchets and knives are made of



FIG. 45.—*Pinnularia major.*



FIG. 46.—*Stauroneis Phœnicenteron.*

the same gritty shells, packed and consolidated in the same way by heat. The sand used for fine iron castings comes from these same silicious deposits of diatom frustules.

These shells are seldom more than $\frac{1}{10000}$ of an inch in thickness, so you can try to esti-

mate how many of them it would take to form the deposit eighteen feet deep under the city of Richmond, Virginia. And if you succeed in that, you may enjoy trying to estimate how many diatoms went to the making of the deposit in Victoria Land,

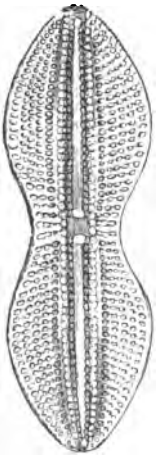


FIG. 47.—*Navicula didyma.*



FIG. 48.—*Pleurosigma formosum.*

which is 400 miles long, 120 miles wide, and of unknown thickness.

You will be prepared to admit after this calculation that diatoms must have been some-

what numerous in the times when these beds were formed. So they were, and so they are now; for, besides the cyclops of which I told you, thirty species have been found in the filter through which the Croton River water is strained at the Astor House, New York; there are three hundred species in Lake Michigan; they form the brown velvet patches on the mud of ponds and marshes; and in some places the waters of the ocean literally swarm with them, from the surface to the lowest depth to which light can penetrate, and from the tropics to the circumpolar regions.

When you see under your microscope a little brown boat-shaped object drifting helplessly along, like an empty canoe, you may be sure that a tragedy has occurred, for this is the deserted house of a little diatom that was swallowed by some other animal which sucked all the life and juices out of it and then cast away the shell; for birds, oysters, whelks, crabs, lobsters, amœbæ, sun animalcules, paramœcii, and even some aquatic plants prey upon diatoms.

The elaborate and artistic manner in which the diatom ornaments his house can be best studied from these empty shells. The shells are spiral, square, heart-shaped, wedge-shaped,

boat-shaped, or circular, and are exquisitely carved, toothed, or dotted. Nothing can exceed the vividness in color of some, or the delicacy in marking of others.

Diatoms grow on branching stems like tiny trees; in clear or muddy, fresh or brackish water; in running streams, or in pools left by the retreating tide.

Owing to their peculiar structure, they propagate by a curious self-division. The shell is composed of two parts which fit together like the two parts of a pill box; and when they multiply, the cover and box separate, the one forming a new box, the other a new cover.

Diatoms are modified by environment, just as people are: if individuals of the same species are placed in different localities, their descendants become so unlike as to be assigned to different species; as the children of twin brothers become entirely dissimilar if one lives in the country and the other in the city.

When the diatom is alive, it moves a certain distance in one direction and then reverses engine and returns on the same track without turning around.

The rhythmic movement of the curious *Bacillaria* is most significant.

The *Bacillaria paradoxa* resembles a bundle of short round rods which seem to be attached to each other by invisible elastic threads. The center rod or frustule remains stationary while those on either side move in opposite directions, stretching out till the ends are barely in contact, and each seems about to part company with the one behind it; but here, as if held by

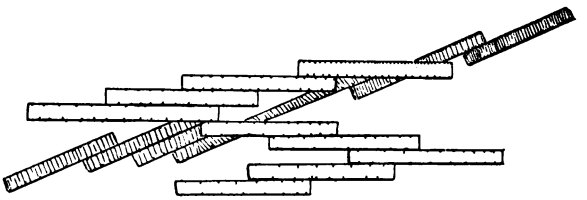


FIG. 49.—*Bacillaria paradoxa.*

an invisible thong, they pause an instant, and then retrace their steps with regular motion, passing the center one, and moving to the limit of motion in the opposite direction. And each frustule keeps time with the movements of the corresponding one on the other side of the stationary frustule.

Not only that, but if the advancing frustule meets with an obstacle which bars its progress, it *does not return at once*, but waits until its mate on the other side has reached a corresponding position on the return journey,

when it takes up the march without marring the rhythm, like a chorus singer who waits for a certain beat so that he may not destroy the harmony.

This motion of the *Bacillaria paradoxa* is supposed to be due to the action of light and heat, since it is in direct ratio to the amount of light and heat received, and ceases in darkness.

Now what can this rhythmic motion and the inability of the rods to break asunder mean, but that the movement is due to the *electricity* in the sunlight, and that the invisible thong which binds the rods is electric polarity?

So we learn from this microscopic bacillaria that light and heat are rhythmical, and we know at last why the planets move in such unvarying regularity and without discord. We know, too, that all the universe is rhythmical, musical, and that there is absolute truth in that beautiful old phrase, "When the morning stars sang together."

And now and then there lives a man who feels this rhythm more keenly than his fellowmen, and is capable of transmitting it through his finger tips, and in him we have a great musical composer. And he, this Mendelssohn or Beethoven, says: "I did not create this

music, I *discovered* it. I *found* it. It is in the air. It is everywhere." And this is true. It is in sunlight, which acts alike upon a bacillaria and a Beethoven. The movement of the bacillaria is part of an everlasting symphony; and as we watch the motion of the paradoxa rods sliding gently and smoothly in perfect unison, or resting till it is time again to join in the symphony, we are listening with our eyes to the music of the spheres; we are learning that man and the stars are part of one great harmony, and sway to the same rhythm which beats upon the bacillaria in the sands on the seashore.

Or, to express it so as to strike a boy's fancy, man and the stars and a grindstone dance to the same music.

CHAPTER IX.

WIGGLERS AND MINUET DANCERS.

Beside all this vast host of animals that swarm in the lakes and ponds, there are immense numbers of insect larvæ, breathing water, eating cyclops and infusoria, tarrying awhile on their way to the upper air, which is the dipter's and neuropter's heaven. But because they are going to their heaven by and by they do not belittle the life they now have, nor persuade themselves that it is a weary pilgrimage, to be endured with patience in view of the recompense to come.

The larva swims gayly about, catching cyclops, smacking his lips when he gets a fat one, and making the most of this world down in the water. After a while he climbs up on a bush and shuffles off his mortal coil by splitting his coat down the back and crawling out of it. He rests awhile, drying his wings and getting his new breathing apparatus into work-

ing order. Then he whets his bill on the branches, and says:

> Fe fo fi fum,
> I smell the blood of an Englishman;
> Dead or alive I will have some!

and he sucks the blood of the first boy he catches fishing.

In the blackest muck of the ponds where there is a rich deposit of decomposed vegetable matter one may sometimes see a great wriggling, as of many fine threads standing in the water, with rapid undulations running up and down through each one. The thread is the *Strephuris*, a worm that is covered with dark, angular marking, resembling a newspaper advertisement. It is very slender, so that it requires the closest scrutiny to detect one even when aided by the movement of the whole company. A single one would escape notice; but, being very sociable, they live in large colonies. Early in spring the edge of some ponds is completely cushioned with these wriggling bodies.



FIG. 50.—*Strephuris.*

They stand on their heads in the mire, and keep up an incessant wagging of their tails. This seems to be their business in life—a business which they have solemnly pledged themselves to follow so long as they all do live. Whether it is work or play is hard to decide. It may be they are dancing the minuet, with their bowings and curvetings. Or they may be serious creatures, feeling that the duties of life require unremitting toil; for they never rest a moment. I once dipped up some, with the muck in which they are found, and put them in a glass can. As soon as the mud settled, there they were, wiggling with the utmost energy. They never stopped except when a little water beetle came among them; then they disappeared as if by magic. But as soon as he was gone they began to stretch up out of their burrows and set to work again. At morn or at eve, by night or by day, week in and week out, for the three months that I kept them, there they were, always standing with their heads in the mud, wriggling. What they eat, how they multiply, or whether they die, this deponent saith not. Their life history seems to be summed up in one word—wiggle.

Some aquatic worms have the ability to turn their middle segment into a head, divid-

ing themselves into two animals. The genus *Lumbriculus* forms a new head when the old one is cut off,—a proceeding which suggests a deficiency in man for which society ought perhaps to be profoundly thankful.

Occasionally we meet people who speak of themselves as "humble worms of the dust," and usually the general bearing of these individuals

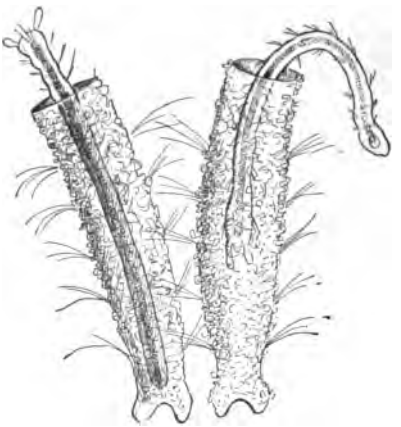


FIG. 51.—*Aulophorus.*

justifies their genealogical claims; but there are other people who might, with equal fitness, claim to be worms of the water, for in their manner of looking at the situation they resemble a certain aquatic worm known as the *Aulophorus*. This worm lives in a sheath made

from odds and ends of *débris*, which is so thin that you may readily see through it. The aulophorus climbs a little way out of the sheath, gazes about, and concludes that things don't look to suit him, and nothing is going right, and the world is all upside down. So he doubles over, thrusting his head into his case farther and farther, and at the same time drawing his heels out, till presently his head is at the bottom of the sheath and his heels are in the air—or rather in the water. Then, of course, the world *is* upside down to him; so presently he has to turn again.

But by this time he is a trifle dizzy-headed and can not see clearly, so matters seem more crooked than ever. After looking about awhile he reverses his position, with the same disconcerting result. Standing on his head, everything is topsy-turvy, till he again careens over, by which time he has become so confused in his mind that he never more can tell what is right side up and what is upside down.

CHAPTER X.

TAKING VACATIONS.

In all this business of making worlds and Beethovens and diatoms, in the making of root feet and hair feet and telescopic feet and whip-lash feet and paddle feet and tentacle feet and feet of sunbeams, poor old Mother Nature must sometimes have grown weary of serious work and have wished for a little recreation.

Maybe it was for this reason that she made some of the curious things we find from time to time, such as the *Stauridia* and the *Cercomonas*, which do not seem to know which way they wish to travel. Perhaps it was when she had made eyes which didn't work to suit her that, by way of ridiculing herself, she made such eyes and eye-spots as those of the Shore crabs, and the *Stomapod*.

Once in a while, too, there is just the faintest suggestion that she felt a trifle out of sorts and was looking around for a good club, as

when she made the *Lepas*. But generally she seems to have been very facetious when not

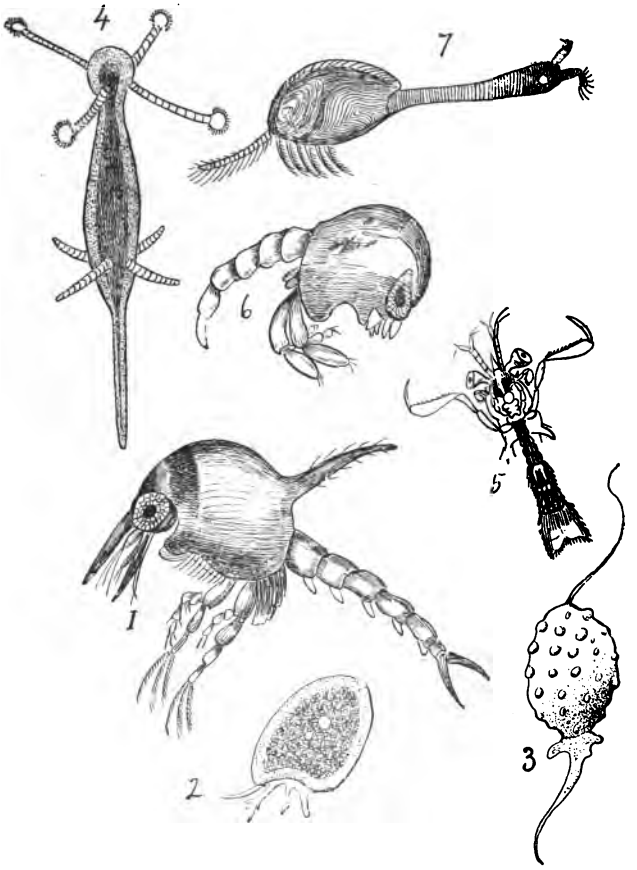


FIG. 52.—1 and 6, *Zoea* of shore crab; 2, *Trinema*; 3, *Cercomonas*; 4, *Stauridia*; 5, *Zoea of Stomapod*; 7, *Lepas*.

very serious, for it was surely in a waggish moment that she made the *zoea* of shore crabs.

Do you think she was tempted to call one of these *Man*, and have an end of her experimenting?

CHAPTER XI.

THE GREATEST JOKE OF ALL.

Boy under Microscope.

A MICROSCOPIST gathered up his basket of bottles, his dipper, and his microscope and went to spend the day at the river side. He took his little boy along, knowing that the child would enjoy the tramp and the opportunity of wading in the water. The man set down his basket and went to work just where the bayou emptied into the river, so that he might get specimens from still or running water at his pleasure. He worked for several hours, while the boy ran along the shore catching butterflies or splashing in the water. The scientist loved the little creatures he was studying, and when he found familiar ones, or when he had examined others of them all he cared to, he put them gently back into the brook so that they might live on unharmed. When he found a rare one or one that he wished to study

further, he put it into one of his bottles to take home. The man and the boy had often been there before, and there were animals in the bayou that had more than once been terrified at finding themselves on the slides under his microscope and had been relieved to find themselves swimming about in the bayou again sound in body and limb. And these had come to wonder what it all meant, and what sort of a machine a microscope was anyway. So they hung about near the shore watching him, wishing they could look into that machine of his, and that he were not such a huge being, so they could see the whole of him at once.

By and by the father wished to go around the bayou to get some green moss growing at the water's edge on the other side. He took a bottle and set off, leaving his son to guard the microscope till his return. The boy sat on the shore beside the instrument and watched the minnows darting about and the waves rippling around his bare feet. But the day was warm and he was weary, so he soon stretched himself on the sand and fell fast asleep.

Presently a minnow swam up and, seeing how tempting his toes looked, tried to nibble them. This made the boy draw up his feet

and roll over, pushing the microscope into the water, and rolling into it himself, till all his body was covered and even his brown curls were wet. But he was so drowsy and the water was so warm that it did not waken him.

Now this was the very opportunity for which the wee water beings had been waiting. They gathered around in great glee and proceeded to inspect him through the instrument. But they were not used to handling microscopes, and they got it wrong end to and wrong side up. This, however, was all the better for them, for, instead of making the boy look larger it made him seem smaller, so they could get the whole of him into the microscopic field. One after another they peeped at him. But the more they peeped and pondered, the more puzzled they became as to what manner of creature he might be. Nothing like him grew on mosses or lived in the water. They had seen parts of him on shore at various times, but, seeing him all together, he looked even odder than they had supposed.

"What manner of animal is he?" they queried. And each had a different theory, but none could decide. "He must be related to the Amœba family," said the Arcella; "for if you will notice, his pseudopodia have buds at the

ends—five buds on each pseudopod—twenty in all. Think what a family! Most of us consider nine a large number."

"He seems to have tried to look like me," said the Vaginicola, "for he is inclosed in a lorica, and so was one that I once saw fall out of a boat."

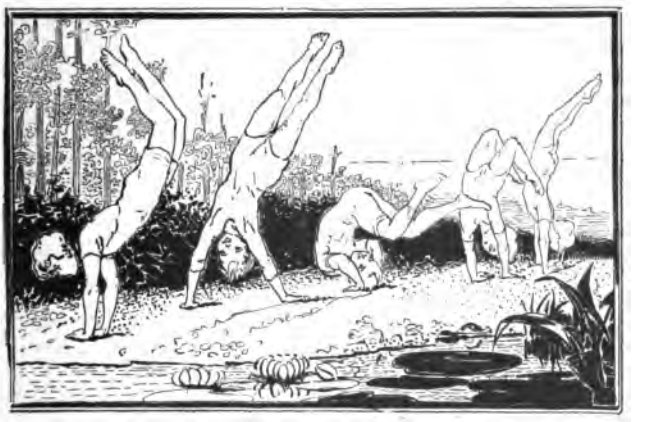
"Yes, he is evidently an attempt at a ciliatus, for just look at the bristles on his head!" said the Stentor.

"But he sometimes swims on his back, and that little one which comes here with the tubs and the washerwoman always lies on its back kicking its four legs in the air as if it were trying to swim like a shrimp," said the Branchipus. "And he has two eyes. Without doubt he was meant for a shrimp, only he didn't get enough legs. He has but two pairs. Perhaps that is because he is still in the nauplius stage."

"I think what you call his front pair of legs are antennæ," said the Daphnia. "They are not set in his head right, to be sure, but I've seen him stand on his hind legs and move those front things about just like antennæ."

"No, those are tentacles," said the Hydra. "I've seen him push food into his mouth with them."

"Yes, but I've seen him walk on the front pair alone," said the Paramœcium. "One day there were half a dozen of them capering around on the beach, and all at once they turned top side down and went walking off one after another in a string, each with his



head down and his hind pair of pseudopods up in the air."

"That proves what I said," replied the Hydra. "He walks with his tentacles, as any sensible being should. I have no doubt that whoever made him intended him for a hydra, although he was rather spoiled in the making."

"No, he's a contortionist," said the Cantho-camptus. "I've seen the washerwoman's nau-

plius flop over with its back uppermost and go crawling off on its four legs; and it did a curious thing as it crawled, for, instead of using its hind *feet*, it doubled them back at the middle joint and allowed the lower half of the leg to drag clumsily along, while it used the knee joints as feet."

"He seems to have been poorly put together in several respects," said the Fairy Shrimp. "Think of having one's branchiæ or breathers *inside* the body, where there's nothing to breathe! And then the absurdity of having one's eyes set *into* one's head, and both looking in the same direction!"

"Think of the absurdity of having two eyes at *all!*" said the Cyclops. "Two eyes to see one thing! Ridiculous!"

"The most ridiculous thing I ever saw about this strange animal," said the little Coleps, "was what happened one warm summer day when several of his kind came down to the shore and peeled off their loricas; and then one of them began to unscrew one of his pseudopods and actually twisted it off and left it lying on the sand, while he and the others jumped into the water and began to kick and splash, sprawling about like frogs. I never had so much fun in my life. I nearly

went into hysterics at seeing that one hind leg kicking in the water while the other lay on the shore like a dead wooden thing. I had to hold my sides for fear my hoops would burst and I'd die laughing."

"How awkward to have pseudopodia which get broken off and have to be replaced by wooden ones! It's a pity he doesn't have a shell to draw them into," said the Arcella.

"The worst of it is that he carries the hard part or shell of him inside, instead of having it outside to protect the soft part of his body, as we do," said the Cypris.

"And his mastax is at the surface of him instead of where the food is to be digested," said the Rotifer.

"He seems to be hollow like the Vorticellæ," said a Bell Animalcule. "But he isn't pretty nor cup-shaped, and what can he want of *two stems?*"

"You are right about being hollow. His head, at least, is," said the Euplotes, "for I've seen several of these animals sit on a log and open a slit which they have in the side of their heads and set clappers going in the great hollow ball, making a ludicrous cackling and croaking like the noises made by frogs. The oddest part of it was that these noises seemed

to be very interesting to them. When one croaked, the others would turn their heads to listen and would watch his clapper wagging, and then another would croak, and they would turn to him; and then another would croak—one after another, almost without cessation; sometimes two or three at once, and every one so attentive and interested! I suppose it is some sort of game similar to that with which the frogs amuse themselves of evenings in the spring. But it is such a very comical performance, and the noises they make are so varied and ridiculous, that it is more entertaining than any frog concert. I should be inclined to think these animals were related to me, because they can run backward; but the fact that they resemble frogs in the noises they make and in their manner of swimming seems to indicate that they are more closely related to the frog family. But I confess that I can't decide *what* they are."

"Well, friends," said the Rotifer, who was acknowledged to be the most brainy one of the company, "this animal is such a jumble, it is clearly impossible to classify him. I can find two and only two explanations for him. You see, he has some points of resemblance to each one of us, and indeed seems to be related to

all of us; but every part of his body is either imperfect in itself or is imperfectly located.

"Now, first, it *may* be that the Creator used him to experiment upon, and put the parts of his body together to see how they would work, and what alterations he should make when he came to create *us*. He may be a sort of trial creature, made before the real work of creation began.

"Or, secondly, he *may* be a conglomerate of all the parts that were left after making us —a batch of odds and ends thrown together at haphazard, with some putty to hold them wherever they happened to stick—a creature made just for the fun of the thing; for—and I hope you will excuse my frankness—but sometimes when I look at some of you—of *us*, I mean—it seems to me that the Creator must have a vein of humor in him which cropped out once in a while in his work. And perhaps when he finished making us and had completed the important part of creation, he was tired and felt the need of a little relaxation, and so he just threw this creature together to see what a ridiculous thing he *could* make, so as to have something to laugh at."

.

Which is it?

PRONOUNCING GLOSSARY.

ACTINOPHRYS (ak-tĭ-nŏf′rĭs).
Amœba, pl. bæ (ā-mē′bȧ, pl. bē).
Amphileptus (am-fī-lĕp′tŭs).
Arcella, pl. æ (ar-sĕl′lȧ).
" ă-cū′mi-nā-tȧ, pointed.
" dĕn-tā′tȧ, toothed.
" mī-trā′tȧ, miter-shaped.
Aëronaut (ā′ĕr-ō-nąt). A balloonist.
Alchemist (ăl′kē-mĭst). An ancient chemist.
Aquatic (ȧ-kwat′ĭk). Living in water.
Atom (ăt′ŭm). The smallest particle of matter that can enter into combination.
Articulated (ar-tĭk′ū-lāt-ĕd). Jointed.
Bacillaria (bas-i-lā′rī-ȧ).
" (paradoxa). Not to be expected; contradictory.
Brachiopoda (brăk-ī-ŏp′ō-dȧ).
Branchipus (brăng-kĭ′pŭs).
Branchiopod (brăng′kĭ-ō-pŏd).
Branchiopoda (brăng-kĭ-ŏp′ō-dȧ).
Canthocamptus (căn-thō-camp′tŭs).
Cercomonas (sẽr-kō-mō′năs).
Charybdis (kā-rĭb′dĭs). A fabled whirlpool near Sicily.
Chilodon cucullulus (kī′lō-dŏn kŭ-kŭl-lū′lŭs).
Ciliata (sĭl-ī-ā′tȧ).
Clathrulina elegans (klăth-rō-lī′nȧ ĕl-ē gănz).

Coleps (kō'lĕps).
Cothurnia (kō-thēr'nĭ-ȧ).
Cyclops (sī'klŏps).
Cypris (sī'prĭs).
Carapace (kăr'ȧ-pās). The shell covering the back of crustaceans.
Chitinous (kī'tĭn-ŭs). Horny; the substance incasing insects and crustaceans.
Daphnia (dăf'nĭ-ȧ).
Desmid (dĕs'mĭd).
Diaptomus (dī-ăp'tō-mŭs).
Dipter (dĭp'tĕr). A two winged insect; a fly; a mosquito.
Débris (dā'brĕ). Rubbish, driftwood.
Dorsal (dôr'săl). Pertaining to the back.
Epistylis (ĕp-ĭ-stī'lĭs).
Euglena (ū-glē'nȧ).
" (trī-quē'tȧ), three-sided.
" (săn-guĭn'ē-ȧ), red.
" (vĭ-rī'dĭs), green.
Euplotes (ū-plō'tĕs).
Eliminated (ē-lĭm'ĭ-nāt ĕd). Caused to disappear.
Encysted (ĕn-sĭst'ĕd). Inclosed in a sac or cyst.
Environment (ĕn-vī'rŏn-mĕnt). The surrounding conditions by which living things are modified.
Extemporized (ĕks-tĕm'pō-rīzd). Made off-hand or under necessity.
Exuding (ĕks-ū'dĭng). Discharging through the pores.
Flagellata (flăg-ĕl-lā'tȧ).
Function (fŭnk'shŭn). The appropriate action of any organ.
Frustule (frŭs'tūl). The shell of a diatom.
Genealogical (jĕn-ē-ā-lŏj'ĭ-kăl). Pertaining to the history of ancestors and their children.
Hydra (hī'drȧ).
Hereditary (hē-rĕd'ĭ-tā-rĭ). Inherited; descended from father to child.
Hypnocyst (hĭp'nō-sĭst). A slumber sac; a cyst in which protozoans lie dormant.

Infusoria (ĭn-fū-sō′rĭ-ȧ). Protozoans found in vegetable infusions.

Incipient (ĭn-sĭp′ĭ-ĕnt). Beginning to be. (This word must not be confounded with "insipient," stupid.)

Inherent (ĭn-hēr′ĕnt). Inseparably associated or involved with.

Jardinière (zhȧr-dē-nyȧr′). An ornamental receptacle for plants.

Joie de vie (zhwȧ-d′-vē′). Joy of life.

Larva (lär′vȧ). The wormlike young insect before it has wings.

Locomotor (lō-kō-mō′tēr). Pertaining to movement.

Molecule (mŏl′ē-kūl). An invisible particle of matter.

Masticating (măs′tĭ-kāt-ĭng). Chewing.

Neuropter (nū-rŏp′tēr). An insect with four net-veined wings.

Noctiluca (nŏk-tĭ-lū′kȧ).

Nucleus (nū′klē-ŭs). A kernel; a central point about which matter is gathered.

Œsophagus (ē-sŏf′ȧ-gŭs). The gullet.

Olfactory (ŏl-făk′tō-rў). Connected with the sense of smell.

Paramœcium (păr-ȧ-mē′sĭ-ŭm).

Protozoan (prō-tō-zō′ăn). One of the lowest or single-celled animals.

Pterodina (tēr-ō-dī′nȧ).

Pyxicola (pĭk-sĭk′ō-lȧ).

Polarity (pō-lăr′ĭ-tў). The condition which exhibits contrasted properties corresponding to contrasted parts, as attraction and repulsion in opposite parts of a magnet.

Prehension (prē-hĕn′shŭn). The act of grasping.

Progenitor (prō-jĕn′ĭ-tēr). A forefather.

Quiescent (kwī-ĕs′sĕnt). In a state of repose.

Rotifer (rō′tĭ-fēr).

Rotifera (rō-tĭ-fē′rȧ).

Recapitulating (rē-kȧ-pĭt′ū-lāt-ĭng). Summing up.

Refracting (rē-frăkt′ĭng). Bending from the direct course.

Spirogyra (spī-rō-jī′rȧ). A fresh-water plant in which are spiral bands of green.

Stauridia (stâ-rĭd′ĭ-ȧ).

Stentor (stĕn′tor).

Stephanoceros (stĕf ă-nŏs'ĕ-rŭs).
Strephuris (strĕf-ū'rĭs).
Silicious (sĭ-lĭsh'ŭs). Made of quartz, as sand.
Thuricola (thū-rĭc'ō-lă).
Trachelocerca (trā-kĕ-lō-sĕr'kă).
Thoracic (thō-răs'ĭk).
Vaginicola (văj-ĭ-nĭk-ō'lă).
Vampyrella (văm-pĭ rĕl'la).
Vorticella (vôr-tĭ-sĕl'lă).
Ventral (vĕn'trąl). The under side of an animal.
Viscera (vĭs'sĕ-rà). The internal organs, especially those of the abdomen.
Viviparous (vī-vĭp'ā-rŭs). Bringing forth the young alive; not exuding the egg before hatching.

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